DECEMBER 26, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Organizing Engineering for Product Development

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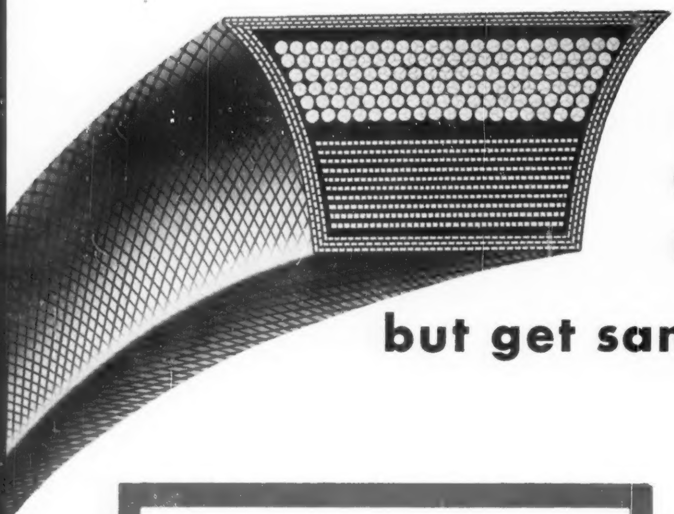
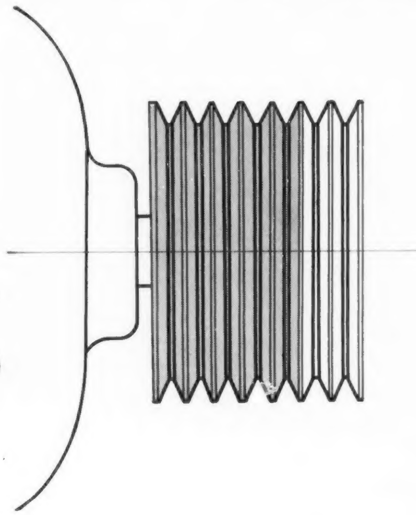
FARNSWORTH

5 Gates Super Vulco Ropes do the work of 7 standard V-belts

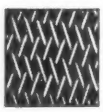


Use fewer belts... but get same HP



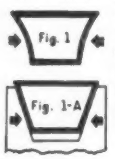
No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)



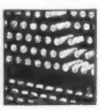
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)



Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

3. Tough, resilient Tensile Cords



Super strong resilient tensile cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads . . . reduce number of belts required . . . save weight and space.

4. High Electrical Conductivity

Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant

Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

Cut sheave width and weight . . . design your drive to benefit from the greater HP capacity of Gates Super Vulco Ropes.

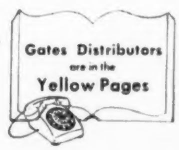
Gates Super Vulco Rope has 40% more horsepower capacity . . . delivers more HP per dollar invested than any standard V-belt. 5 Gates Super Vulco Ropes will do the work of 7 standard V-belts.

Sheaves with fewer grooves cost less . . . weigh less . . . occupy less space. Your drive design is improved.

Helpful drive data is quickly available to you. Simply call your nearby Gates distributor for advice from a Gates V-Belt Specialist. Stocks carried in industrial centers throughout the world.

The Gates Rubber Company

Denver, Colorado



TPA 264A

Gates — The Mark of *Specialized* Research

Gates Super Vulco Rope Drives

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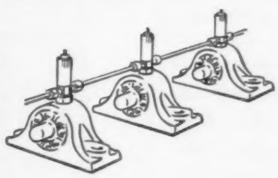
Design for
Automatic Lubrication From One Central Point

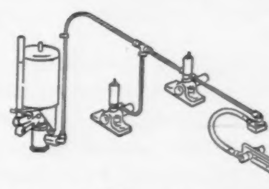
with an ALEMITE Accumatic® System

FASTER . . . FOOLPROOF . . . LESS COSTLY!

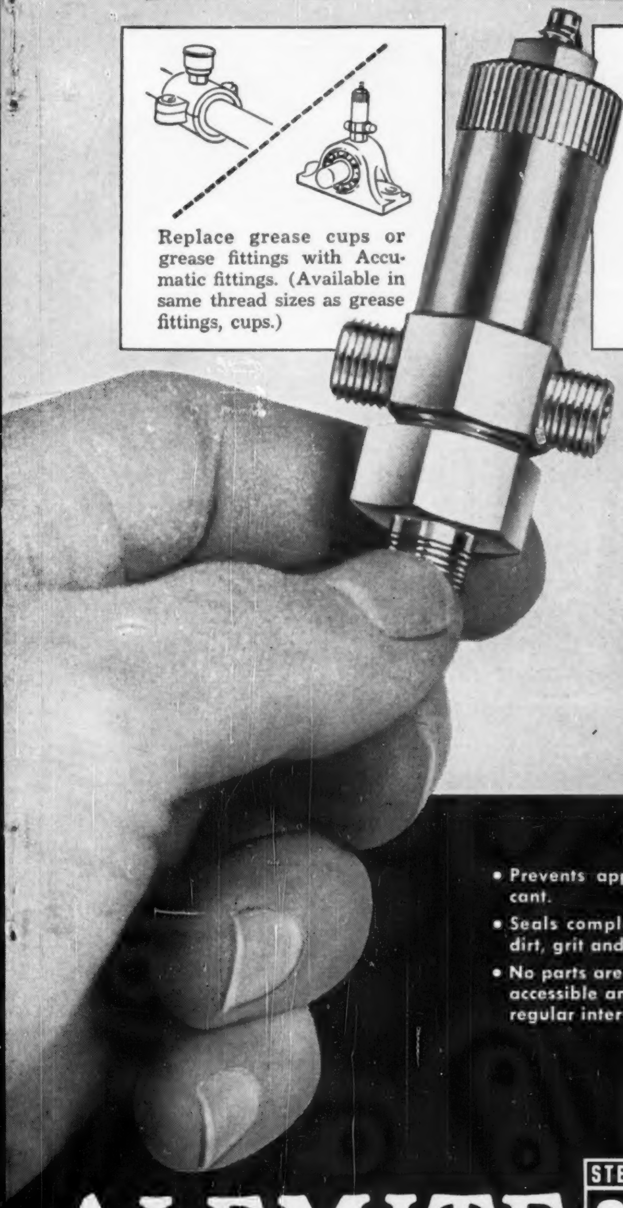
Replace grease cups or grease fittings with Accumatic fittings. (Available in same thread sizes as grease fittings, cups.)



Connect Accumatic fittings with copper tubing. (Alemite has tubing, clips and accessories for easy installation.)



Connect sliding, rotary or oscillating parts into tubing system. (Flexible hose and swivels for moving parts.)

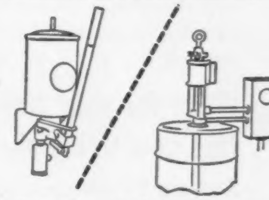


Type 1 Accumatic Valves

For fluid oil or light grease. In range of sizes, delivering from .005 to .100 cu. in. of lubricant. Various shapes: Tees, straight-thru, inserts, angles. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation available.

Factory-tested—field-proved!

Grueling field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to *122 years of twice-a-day service!*

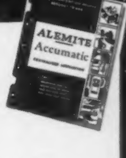


Provide central pump to supply lubricant to system. (Ordinary hand pump or fully automatic barrel pump.)

ALEMITE ACCUMATIC ADVANTAGES!

- Prevents application of wrong lubricant.
- Seals completely against damaging dirt, grit and water.
- No parts are neglected—lubricates inaccessible and dangerous bearings at regular intervals.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers *exact* amount of lubricant to bearing.

FREE! Alemite Accumatic Catalog



Alemite, Dept. BB-127
1850 Diversey Parkway, Chicago 14, Illinois
Please send me my free copy of the complete Accumatic Catalog.

Name ....
Company ....
Address ....
City .... Zone ...... State ....

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ALEMITE REG. U. S. PAT. OFF.

STEWART SW WARNER

A Division of STEWART-WARNER CORPORATION

Now you can get standard sizes in C/R End Face Seals!

Chicago Rawhide now announces the availability of a complete new line of Standard End Face Seals to meet the widest possible range of sealing requirements. For sizes or conditions beyond the range of Standard End Face Seals, C/R engineers will continue to cooperate with you on special designs. Their experience in sealing applications is unmatched — your assurance of getting the correct seal for the job.

Write for your free copy of this new C/R Bulletin ⟶

Bulletin EF-100 includes complete envelope space data on C/R Standard End Face Seals and mating rings to help you select the correct size for your equipment design:

- Size range table in two series — long and short — from ¾ to 4 inch shaft diameter.
- Size range table on mating rings.
- Typical seal installations for internal and external pressure.
- Special instructions on how to order.

OIL SEAL C/R DIVISION

CHICAGO RAWHIDE

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Hamilton, Ontario.
Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-Metallic Gears

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THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U.S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U.S. government installations, performing design engineering of products are also eligible.

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Engineering News Roundup

Low-Temp Research Yields Hi-Speed Computer Element

Memory Element Makes Use of Superconductivity Principles

LOS ANGELES — Low temperature physics research work has resulted in the development of a high-speed computer memory element which makes use of superconductivity principles to achieve both storage of information and instantaneous switching. Developed in the Ramo-Woolridge Aeronautical Research Laboratory, the device is called a Persistor and is a miniature bimetallic, printed circuit which operates at a temperature a few degrees above absolute zero. It requires very little power for operation and has been designed with switching times as short as 1/100 millionth of a second.

The Persistor was designed for use in the "memory" unit of an electronic computer and improves the access time to the memory 10 to 100 times over present methods.

The new unit makes use of the superconductivity phenomenon exhibited by various metals at low temperatures to achieve both the switching and signal storage functions required of a computer memory element. (Also see Cryotron, MACHINE DESIGN, March 7, 1957, Page 5.)

Essentially, the Persistor is a loop composed of segments of two metals, both of which are maintained in a superconductive state at a very low temperature. One segment of the loop is of a metal chosen so that the passage of a small current (the critical amount depending on its temperature) through it causes it to change from its superconductive to its normal resistance state. A subcritical current is induced in this loop and continuously circulates around it for an indefinitely long period, the direction of this current representing the information being stored.

Direction of current in the loop can be determined at any time by impressing an interrogating current pulse on the loop. The direction of the current in the Persistor is clearly indicated by the presence of a voltage pulse upon interrogation.

According to the company, maintaining the low temperatures required for Persistors offers no ob-

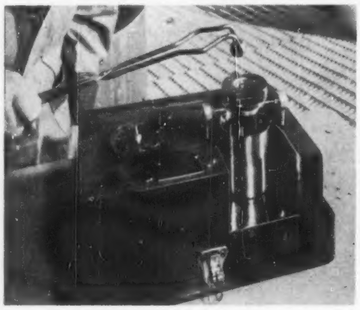
WHIRLING ATLAS COMPONENTS is the job of this new centrifuge at Convair Astronautics Div., General Dynamics Corp. The big machine can whirl a 1-ton load at 121 rpm. Components are bolted into the 3-ft long steel test capsule and balanced by weights added to far end of the 10-ton, 40-ft boom. Temperatures in test compartment can be varied from −100 F to 350 F. A third environmental factor—vibration—will be possible with addition of a shaker mechanism. Drive system consists of three hydraulic motors with combined capacity of 125 gpm under 5000 psi. Hydraulic pumps are driven by electric motors developing a total of 400 hp. Braking is accomplished by reversing fluid flow in hydraulic motors.

stacle to their immediate use in computers. Recent advances in helium liquefiers make it feasible to maintain low temperatures at a relatively negligible cost.

Use Magnetic Properties To Measure Quenching

Device Times Metal's Return to Magnetic State

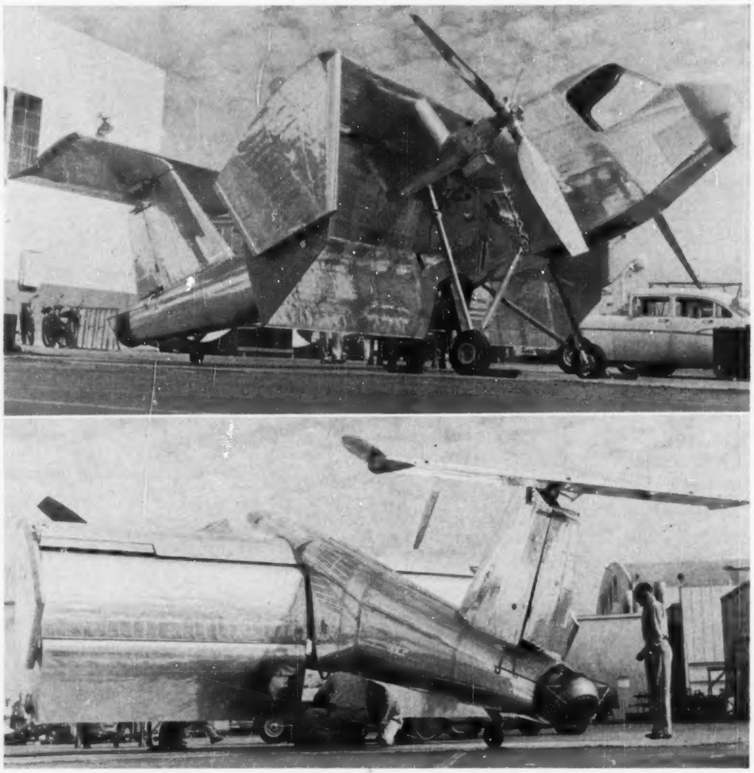
WARREN, MICH.—A new device promises accurate measurement of the quenching effectiveness of liquids used in the heat-treat processing of steel. The Magnetic Quenchometer, developed by the



General Motors Process Development Section, uses the magnetic properties of metal to compare various quenching rates of oils, water, brines, or other liquids.

Operation of the Quenchometer is based on the principle that any magnetic material heated beyond a certain temperature or Curie point loses its magnetism. But it regains this when cooled below the Curie point.

As an example, a 1-in. nickel ball has a 670 F Curie point. Prior to a test with a quenching fluid, it is heated to 1600 F where it becomes essentially nonmagnetic. Dropped into a cage suspended in a cup of the quenching liquid under test, the ball cools to the point where it regains its magnetism. It is attracted toward a magnet adjacent to the container and carries the cage with it. A circuit measures time from the instant the ball is dropped into the cage until it is attracted to the magnet. This interval is a measure of the fluid's quenching ability.



VERTIPLANE, developed for Army and Navy by Ryan Aeronautical Co., is the latest edition in VTOL aircraft. Unlike the "tail-sitting" Ryan Vertijet, Vertiplane will take off and land vertically, hover and fly forward, all in a horizontal attitude. Double retractable flaps extend far below the wing trailing edge and deflect the propeller slipstream downward to provide vertical lift. Flaps are retracted for transition to horizontal flight. End plates at wing extremities provide structural support for the large flaps, and confine slipstream to the flap span. Powerplant is a Lycoming T-53 engine located in the fuselage. Vertiplane will carry two passengers; has a gross weight of 2600 lb. Wingspan is 23.5 ft; length, 28.7 ft.

Will Try Foundry Methods For Aircraft Steel Alloys

DALLAS—To develop foundry methods for casting high-strength steel alloys for supersonic aircraft of the future, a prime contractor will work with three foundries over a two-year period. According to recent announcement by the Air Materiel Command, Chance Vought Aircraft has been awarded a $1.1-million Air Force contract.

Primary purpose of the Air Force project is to develop processes of casting steel in the complex shapes required by the aircraft industry and capable of withstanding extreme temperatures. With the speeds of tomorrow's planes projected into ranges from 1500 to 2300 mph, metals must withstand temperatures up to 1000 F. Development data obtained will be made available to all foundries making castings for military aircraft.

Where parts manufactured by

Front Cover

A Christmas-colored arrangement of function blocks, typical of company organization charts, is George Farnsworth's interpretation of "Engineering for Product Development" by Phil Marvin on Page 70.

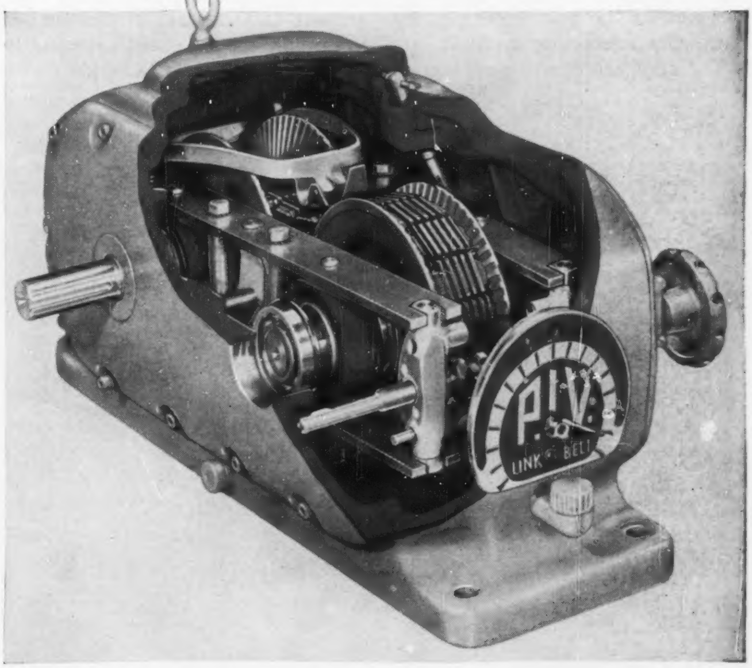
LINK-BELT P.I.V. means positive, infinitely variable speed control

Where modern production machines and operations demand extremely accurate transmission of power with variable speed control, no other variable speed drive can match the efficiency of the Link-Belt P.I.V. Here's how it works.

Because it employs an exclusive metal, self-tooth-forming chain, Link-Belt P.I.V. permits instant and accurate speed changing without perceptible loss of speed—regardless of load. And the variation can be accomplished without stopping the driven machine.

A mere turn of the control screw simultaneously varies effective diameters of conical wheels located on the input and output shafts. In turn, these radially grooved wheels mesh with the self-tooth-forming chain assuring positive selection of speed.

Call your nearby L-B office for Book 2274.

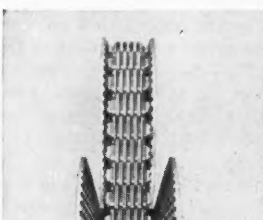


LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

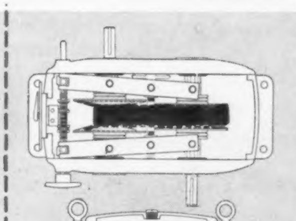
14,318

LONG-LIFE ACCURACY and application flexibility of Link-Belt P.I.V. are unmatched by any other variable speed drive. It's available in 8 sizes and 16 standard types, in capacities from ½ to 25 hp—for horizontal or vertical mounting. Compact design simplifies installation as a separate unit or a built-in part of a machine. Even greater application flexibility can be gained by making motor and helical gear sets integral parts of the P.I.V. Of all-metal construction, P.I.V. is totally enclosed, automatically lubricated.

How LINK-BELT P.I.V. differs from other variable speed drives



POSITIVE MESH of self tooth-forming chain with grooved wheels assures full-rated hp at output shaft. All-metal construction . . .



PREVENTS SLIPPAGE because the P.I.V. drive chain does not depend on friction and is unaffected by atmospheric conditions.

UNMATCHED ACCURACY is demonstrated by this actual comparison of maintained rpm of P.I.V. and three other variable speed drives.

GREATER COMPACTNESS results from short-center arrangement of drive mechanism. Some P.I.V. models save 50% on floor space.

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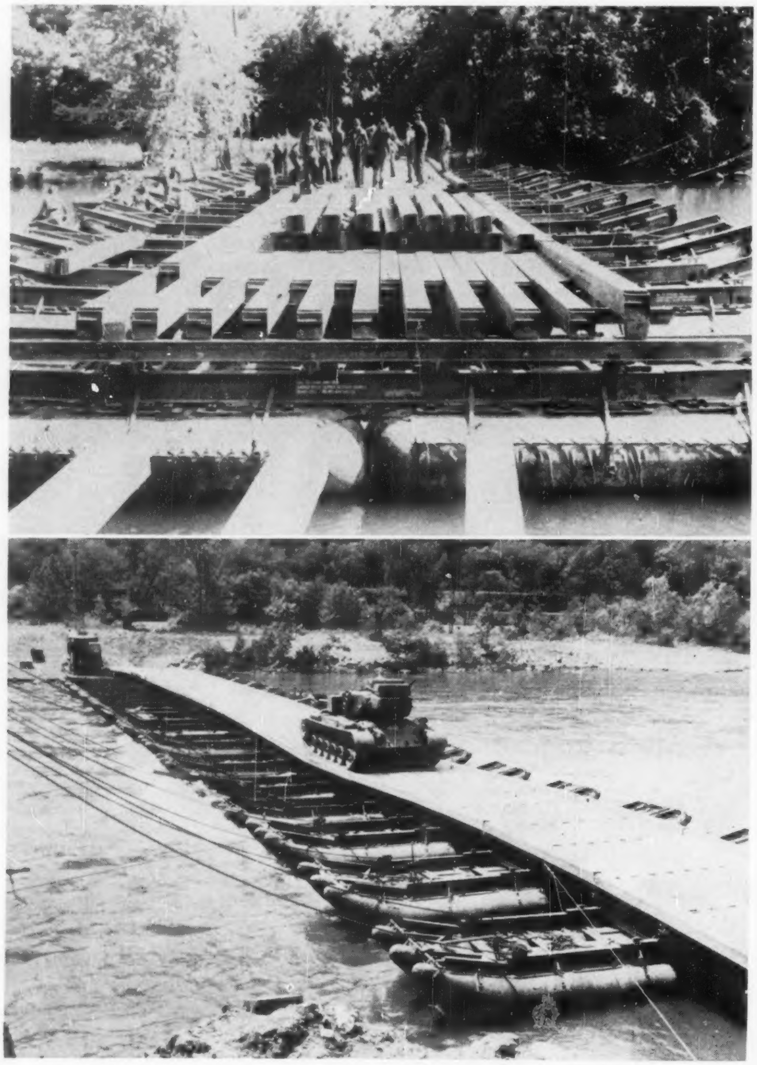
casting can be substituted for parts made by other methods, considerable dollar savings will be effected for aircraft companies. A comparable part produced by casting may cost as little as one-tenth as much as the part fabricated by more time-consuming methods.

The contract covers selection of three foundries to do development work on actual aircraft parts designed by Vought; laboratory tests to select steel alloys capable of being stressed to 180,000 to 220,000 psi and ways to make them castable; and future production of castings having tensile strengths from 260,000 to 300,000 psi.



FLEXIBLE FLOATING BRIDGE is unlike previous rigid structures—note area under tank—and is completely air transportable. Heaviest single component is a 750-lb neoprene-coated nylon float. Pneumatic half floats, joined to form complete units, serve as supports at 15 ft intervals. Deflated floats are stored and transported in canvas carrying bags. Hollow aluminum deck sections weighing 225 lb are staggered side-by-side to serve as road surface. Steel beams and plywood panels provide stiffness and distribute load to floats. Designed by Army Engineer R & D Laboratories, the new bridge can be manuualy erected at rate of $1\frac{1}{2}$ ft per min.

Topics

A Sputnik by any other name might be called 1957 Alpha 2, if identified by the astronomers' system of labeling newly discovered natural objects. In this Greek-letter system, the comparative brightness of objects in a group also is indicated, by numerals. Thus, Sputnik would be 1957 Alpha 2; its brighter rocket, 1957 Alpha 1; Muttnik, 1957 Beta.

• • •

A new low, −102.1 F, was measured at the IGY Amundsen-Scott South Pole Station on September 17. Mean temperature at the Pole throughout the past winter was −73 F; high was a balmy −26 F.

• • •

Coolness, to a lesser degree, is gaining in popularity among U. S. home owners, according to figures compiled by Carrier Corp. Carrier reports that 160,000 home cooling units were installed in 1957—10,000 more than in 1956—and predicts 250,000 will be required next year.

• • •

E pluribus unum in reverse is accomplished by a new automatic money-changing machine that accepts a dollar bill and returns two quarters, three dimes and four nickels. A discerning device, it will take wrinkled or badly worn bills, but will reject denominations other than one dollar, foreign currency, and fake money. Function of this nonprofit middleman is, of course, to supply coins for other vending machines. It is made by A. B. T. Mfg. Corp.

• • •

Guided-missile, nuclear-powered cruiser is being built for the Navy. It will be the Navy's first nuclear-powered surface ship. Keel of the 721-ft *USS Long Beach* was laid December 2, just 15 years after the day nuclear energy was first obtained in usable quantities.

• • •

Medium of metals was used to create a 10 by 25-ft panoramic mural in the Penn-Sheraton Hotel, Pittsburgh. The first of its kind to be composed of modern industrial materials in a panel of semi-abstract contemporary art, the mural portrays twentieth-century Pittsburgh. Stainless steel sheet and anodized aluminum were fashioned by soldering, sawing, hammering, drilling, and wire brushing into sky, rivers, buildings, bridges and roads. Decorated glass panels flank the mural.

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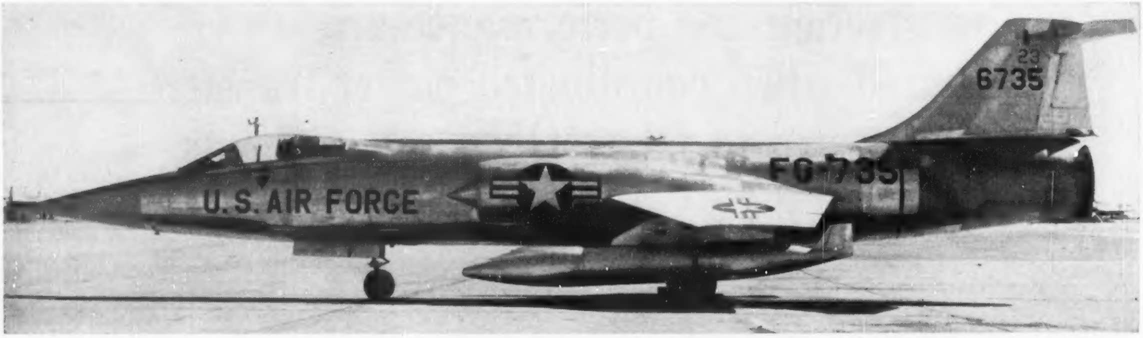
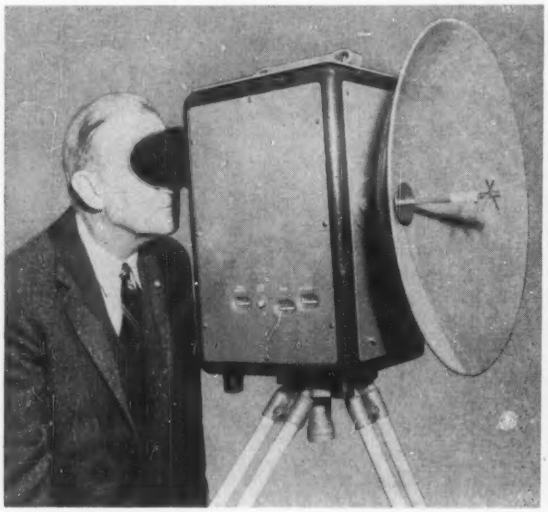
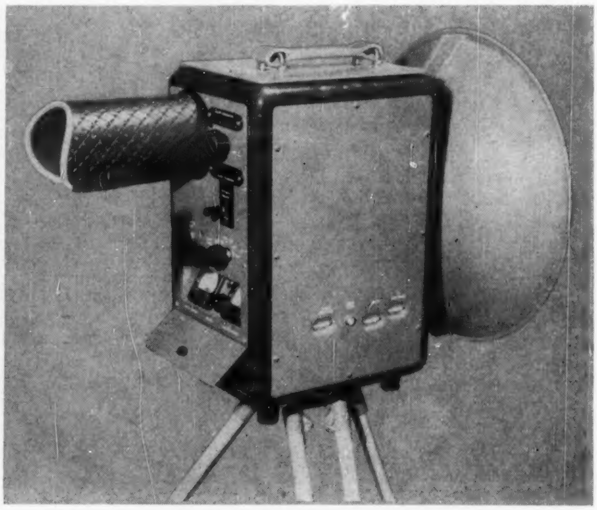


MORE RANGE FOR THE F-104 is provided by new torpedo-shaped pylon tanks, similar to the underslung pod on the B-58. Designed to match the silhouette of Lockheed's fast Starfighter, the jettisonable tanks each contain 200 gal of fuel for added mission range. Pylon attachments can also be jettisoned. Tanks are 20½ in. in diameter and 17½ ft long. Fins on tail of the tank add aerodynamic stability.





The remarkable Tellurometer surveying instrument applies a refinement of radar to the job of measuring distances. Lightweight, portable, easily erected, its simplicity of operation requires little training and no special knowledge of electronics. Accuracy is about one part in 300,000 ± 2 in. at distances up to 35 miles.

New Radar Surveying Instrument Cuts One-Month Job to One Hour

Device May Speed Building Of Federal Highway Network

WASHINGTON—A completely new instrument for measuring land distances, the Tellurometer, was introduced recently to the surveying profession in the U. S. It has been used with outstanding success by its designers, the South African Council for Scientific and Industrial Research, and by the U. S. Coast and Geodetic Survey. The instrument is expected to find extensive use in the coming federal highway program.

Tellurometer operates in the ultrahigh frequency region, measuring the travel time of radio waves over the length to be determined. Accuracy is within a fraction of a millimicrosecond. Measurements can be made day or night—visibility is immaterial.

To measure a single line, one master station and one remote station are required, with an operator at each post. A built-in duplex radio-telephone is included in the system. Procedure is controlled by the operator at the master station by means of the R/T communication, and consists primarily of tuning adjustments and a switching sequence with readings being taken from a cathode ray tube. Measurements are quickly made, with less than 30 minutes required for unpacking, setting up, taking readings, and repacking the equipment.

To achieve its remarkable accuracy, Tellurometer requires certain corrections for meteorological conditions, since these affect the velocity of propagation of radio waves. Under normal circumstances, however, simple meteorological measurements at master and remote stations are sufficient.

The impact of Tellurometer on

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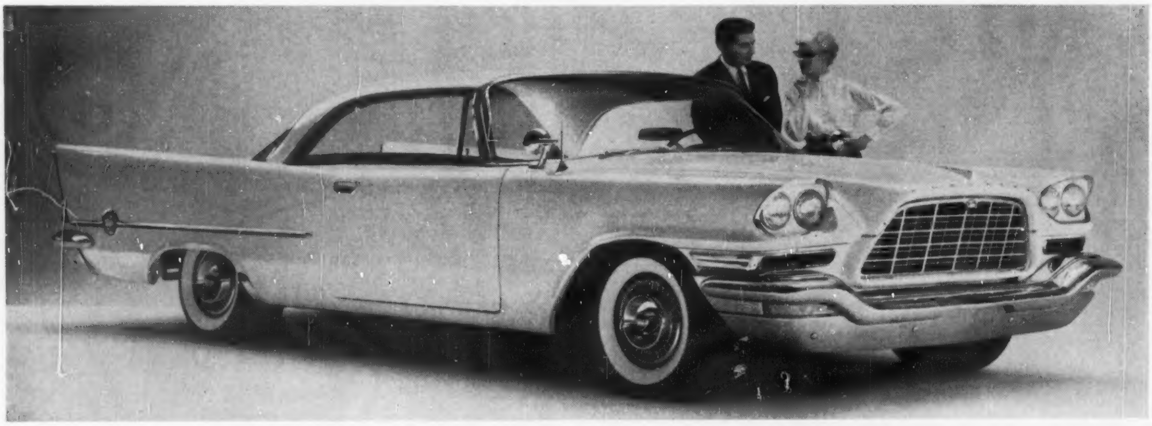


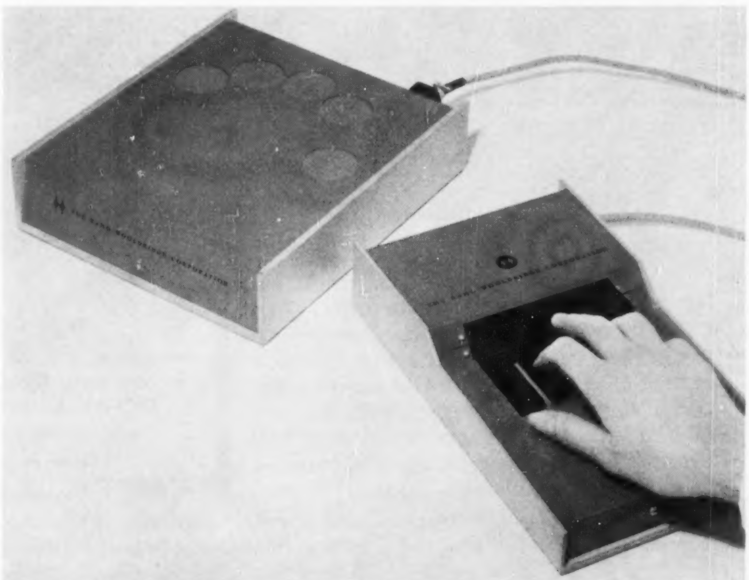
CHRYSLER'S MODEL 300 D for 1958—fourth edition of the limited-production 300 series—retains the familiar clean lines and restricted use of chrome. Electronic fuel injection is offered this year for the first time, boosting horsepower to 390 at 5200 rpm. With conventional carburetion, the 392 cu-in. engine is rated at 380 hp. Torque is 435 lb-ft at 3600 rpm. Tappets are mechanically actuated to eliminate possibility of hydraulic pump-up at engine speeds above 5000 rpm. Overall height of the new model is 55.2 in.; length, 220.2 in.; wheelbase, 126 in. Air scoops below headlights cool the special 12 x $2\frac{1}{2}$-in. power brakes.

surveying methods was illustrated in recent public trials held in England. There, the geodetic base upon which much of the control of Great Britain rests, was measured with Tellurometer by two men working less then 1 hr. Conventional tape measurements required 20 men working 30 days.

Transmits Touch To Aid the Deaf

Communicator Also Potentially Stepped-Up Stenotype Machine

Los Angeles—A step toward eliminating communications barriers of hearing defects was disclosed recently by Dr. Edgar Lowell of the John Tracy Clinic with announcement of a new device which will provide the deaf with additional means of instant communication. Dr. Lowell said the unit, called the Teletac, will be used by the Clinic in research work with deaf children in several fields, including learning of lip reading, speech learning, and acquiring language concepts.

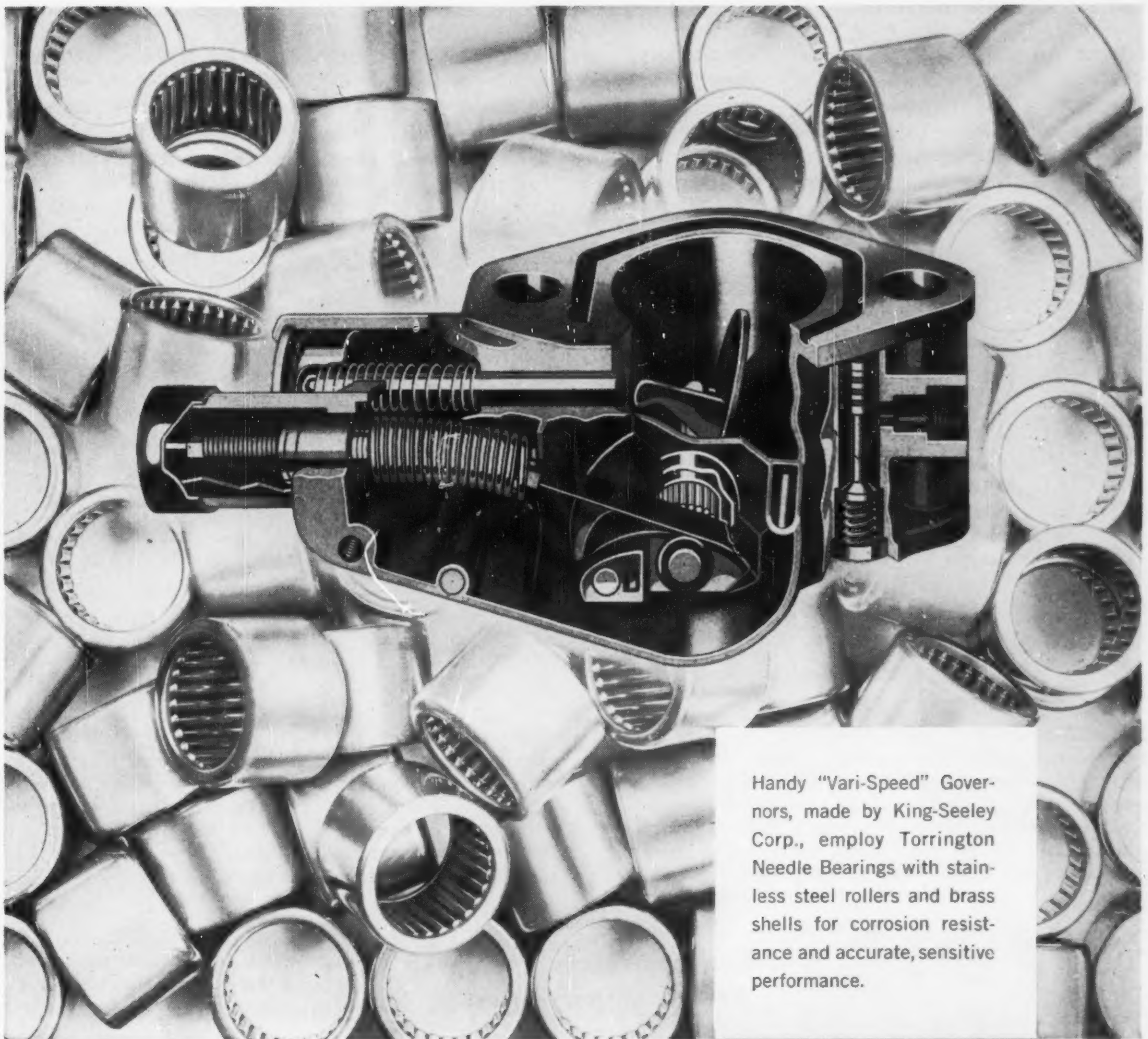


Touch communicator is designed to give deaf persons an additional means of instant communication. In operation, the five fingers of the "speaker" press sensitive vibration-sending piano keys on one unit while the five fingers of the "listener" rest on sensitive receiving diaphragms on the other.

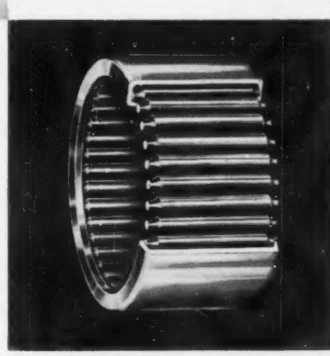
The Teletac was presented by the Ramo-Woolridge Corp., which credited design engineer Joseph Hirsch with development of the device. It resulted from several years of research and development work begun as a hobby by Hirsch.

Employing two frequencies, the Teletac enables a deaf person to transmit 637 words or symbols. However, the problem of optimum coding is yet to be solved. "This can come about only by a great deal of work at the Clinic," Dr. Lowell said, "and will involve studies with the deaf children . . ."

Coding of the alphabet was achieved on the pilot model by using combinations of finger pressure on the keyboard. With only one frequency, coding was relatively simple. A pressing of the



Handy "Vari-Speed" Governors, made by King-Seeley Corp., employ Torrington Needle Bearings with stainless steel rollers and brass shells for corrosion resistance and accurate, sensitive performance.



Twenty years later—still preferred!

Since the first installation before World War II, Torrington Needle Bearings have been used in Handy "Vari-Speed" Governors. These units govern engine speed for automobiles, trucks and buses by balancing air-flow pressure on the throttle plate against a calibrated cam-spring mechanism.

Torrington Needle Bearings were first used to insure sensitive response and regulation at low velocity and tension values—and are still preferred. They provide efficient anti-friction operation in the simplest and most compact design possible.

In every type of service, Torrington Needle Bearings have provided long, trouble-free and dependable service—as in so many other automotive applications. For engineering assistance on your requirements, see your Torrington representative. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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key by the thumb of the sender emitted a signal to the thumb of the receiver and represented the letter *A*. The index finger represented *B*, and middle finger *C*, etc. Other letters were transmitted by simultaneous pressing of two, three, or four keys. With two frequencies in the present model, coding will be more complex but will increase speed of communication.

Knowledge gained at the Clinic through use of the communicator may eventually result in a multiple frequency coding which could successfully be applied to a speeded method of communication superior to any known today.

NUMERICAL CONTROL APPLIED IN SHOP means simplified machine tool operation. Point positioner system, manufactured by Electronic Control Systems Inc., positions table and selects drills as directed by punched tape, for drilling accuracy within 0.001 in. "Absolute positioning" design and "closed servo loop" principle eliminate error buildup and ensure precise repeatability. Tape punched on first unit programs control unit to position servo table and select drill sizes. No further attention is necessary after punched tape is placed in control unit and start button is pressed. According to the company, the system can be adapted to any point positioning setup: Spot welding, riveting, engraving, tapping, countersinking, template plotting.

CONSOLE BRAIN for control of point positioning system translates information from perforated tape into electrical commands that position the table and operate the drills. Engineering changes during a production run can be made by altering the original tape. Use of only off-the-shelf components makes it possible for most maintenance to be on a remove-and-replace basis.

Interwoven Wires Simplify Magnetic Memory Arrays

NEW YORK — A new concept in memory devices is expected to make possible memory systems which are simpler to manufacture than present systems. Named the Twistor process and developed at Bell Telephone Laboratories, the concept may have extensive applications in computers and electronic switching systems where high capacity memories are essential.

Interweaving horizontal copper wires and vertical magnetic wires, much as window screen is woven, opens the way for the construction of magnetic memory arrays. Such a device is similar in appearance to a ferrite core array, but without the cores.

Twistor gets its name from a characteristic of wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetization from a longitudinal to a helical path. This permits the magnetic wire itself to be used as a sensing means.

In practice, the circular magnetic field is set up by a current pulse passed through the magnetic wire, and the longitudinal field by a current pulse through the copper wire. The copper wire is positioned perpendicular to the magnetic wire. Thus, storing a "bit" requires two coincident current pulses.

Readout is accomplished by overdriving the longitudinal field in the reverse direction. The readout signal is sensed across the magnetic wire. Also, a favorable increase in the output signal is obtained.

Investigation is now under way to determine optimum size and composition for the magnetic wires. It appears that a conductor plated with magnetic material may have some advantages; diameters as small as 0.001 in. appear feasible.

At least 10 bits per inch may be stored on such a wire without adverse interaction.

Present indications are that the drive circuits for a Twistor array can be readily transistorized. Thus, a memory system using the Twistor concept will reportedly retain all advantages of ferrite core or sheet systems, will be simpler, cheaper to fabricate.

WORLD'S LARGEST IMPACT EXTRUSION is claimed by Harvey Aluminum Co. for this aluminum missile body section. Extruded on a production basis, the impact is 32 in. long, 14 in. in diameter, has a wall thickness of 0.875 in., and is stepped at one end. Weight is 112 lb. Alloy 2014-T6 was used; finish is 125 mu-in. rms or better.

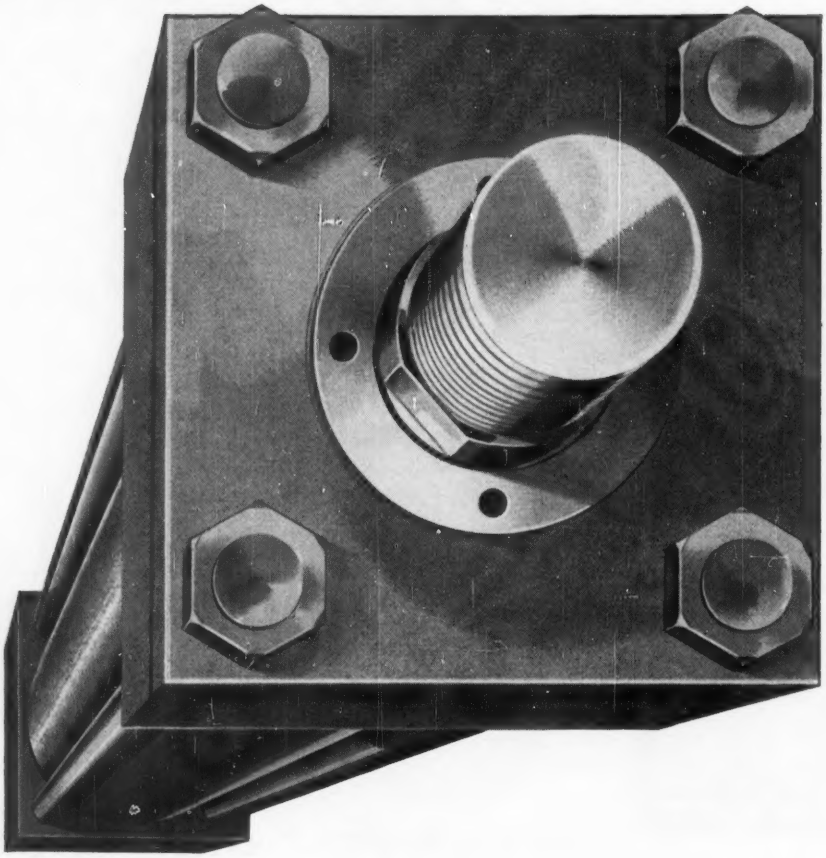
Practical Program Spurs Study of Science

NEW YORK—As part of the national effort to step up scientific education, the American Institute of Physics is embarking on a program to improve the quality and quantity of sciences taught in high school and college.

To achieve these objectives, the Institute has added two visiting college professors to its staff.

(Please turn to Page 22)

AT YOUR REQUEST...



ANKER-HOLTH

Hydraulic Cylinders now available in Square Head design

Positive Trouble-free Performance

Anker-Holth Division, for 18 years designers and manufacturers of quality air and hydraulic power cylinders, now offers a standard line of all steel, high pressure square head tie rod cylinders. Important new operating features and design achievements assure positive controlled power for a wide range of industrial applications.

Standardized Mountings for Interchangeability

Conservatively rated at 2000 P. S. I. working pressure and 3000 P. S. I. non-shock pressure every cylinder is proof tested at 4500 P. S. I. All mountings are available, standard bores from 1½ to 8 inches. Standardized mountings provide complete interchangeability with most makes of square head cylinders. The Anker-Holth "□" line meets all J. I. C. specifications.

For more information contact your local Anker-Holth representative or Anker-Holth Division, Port Huron, Michigan. YUkon 5-7181

McDOWELL

ANKER-HOLTH DIVISION

THE WELLMAN ENGINEERING COMPANY

2726 CONNOR STREET, PORT HURON, MICH., U. S. A.

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Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

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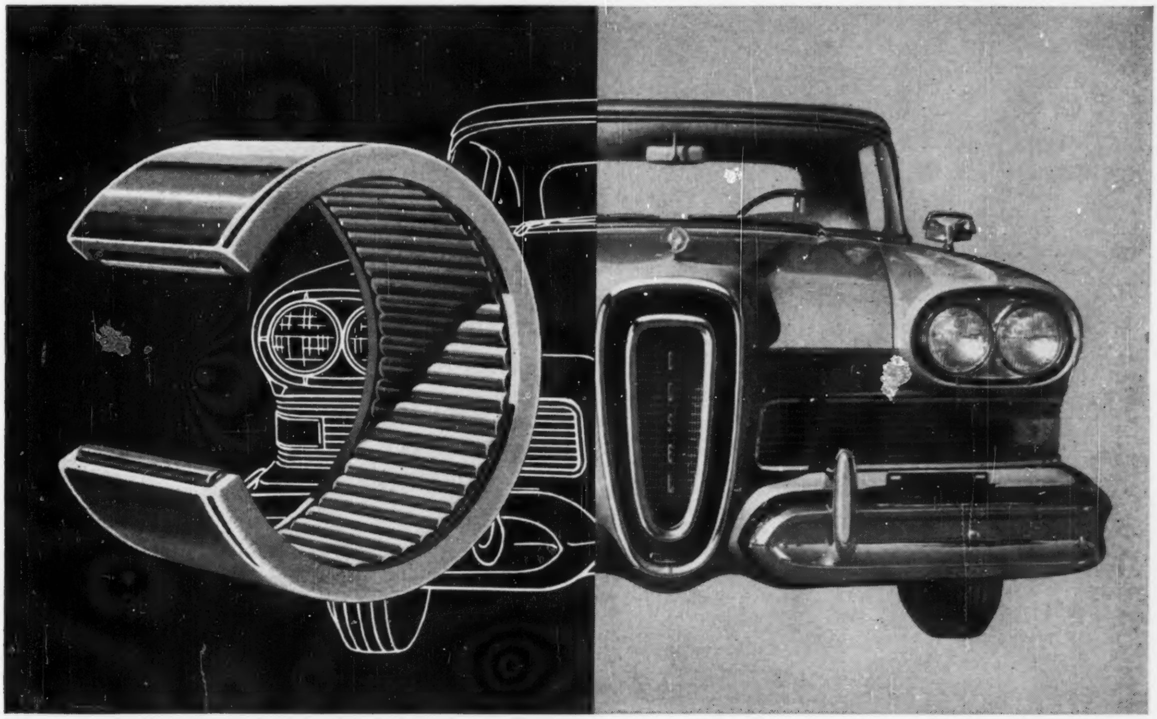
America's newest thin-shell needle bearing



. . . now in America's newest automobile

Developed with the cooperation of Ford Motor Co., these KAYDON bearings are used in the automatic transmissions of Edsel as well as Ford and Mercury

The 1958 Edsel, America's newest automobile, backed by more than 1,250,000 road-test miles, employs in its transmission, America's newest thin-shell needle bearings, introduced by Kaydon of Muskegon. Why?

Proven in Ford-O-Matic and Merc-O-Matic transmissions, these Kaydon thin-shell needle bearings deliver 46% more bearing capacity.

Greater effective length of spherical end rollers does it. Important too, simplified construction, pre-packed lubrication, saves money . . . and saves valuable time on the assembly line too! See table below for standard Kaydon thin-shell needle bearing sizes.

AVAILABLE FROM STOCK IN 5 STANDARD SIZES:

SHAFT DIAMETER	HOUSING BORE	WIDTH
1.0605"	1.3130"	.500"
1.1250"	1.3755"	.750"
1.1250"	1.3755"	1.000"
1.1875"	1.5005"	.625"
1.3750"	1.6875"	.625"

For other sizes and complete specifications, write or call KAYDON of Muskegon today.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter bore to 160" outside diameter . . . K-573

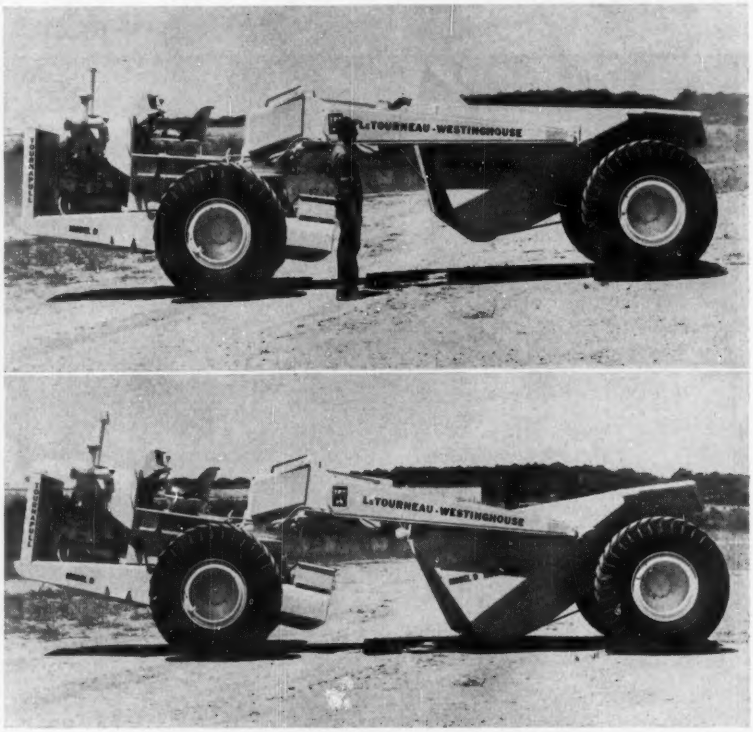
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 413 on Page 19

(*Continued from Page* 15)

Prof. Grant O. Gale is making a nationwide survey to determine how television and motion pictures can be used to provide teaching in spite of the great shortage of science teachers. Dr. William C. Kelly administers a new program of visiting lecturers in physics.

This lectureship program is bringing some of the nation's most distinguished physicists, including Nobel Prize Winners, to over 100 colleges which ordinarily do not have contact with these scientists. Each visiting scientist stays several days on the campus of the college he visits so that he may give lectures, talk with students, and assist faculty members with curricular and research problems.



LOW-LOADING REAR DUMPER, designed for mining and other close-clearance jobs, is a new, low-silhouette version of LeTourneau-Westinghouse Co.'s 11-ton Tournapull. Low-loading feature, below, permits lowering of the dump bowl to height of 65 in.—19 in. less than previous models—to accommodate small, tractor-mounted front-end loaders. Bowl is raised and lowered by electric motor operating a reel and cable. Low-loading action is controlled by a simple pneumatic system. A pair of air rams engage mechanical stops on the dump bowl to hold the unit in travel position; retract to allow the bowl to move downward. Limit switches stop the bowl motor at travel position and maximum low position.

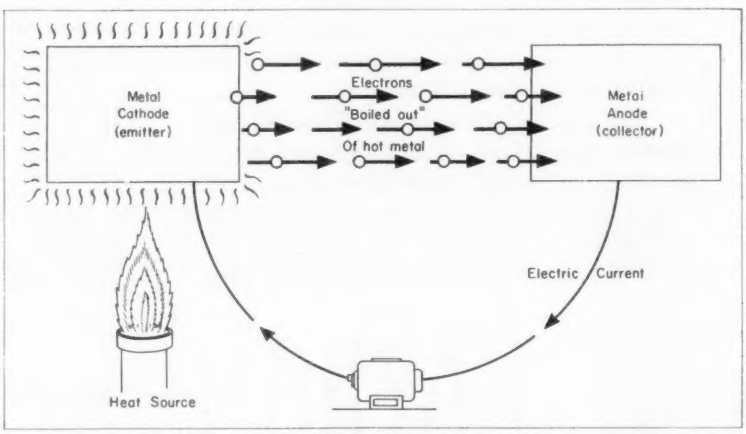
Laboratory Device Changes Heat to Electricity

Thermionic Converter Shows Encouraging Efficiency

SCHENECTADY, N. Y.—Because electrons can be "boiled out" of a hot metal surface, the direct production of electrical energy from heat input has been achieved in a unique device. Developed at the General Electric Research Laboratory, the new thermionic converters combine several known scientific principles in a unique manner.

Two electrodes within a tube-like device are maintained at high temperatures. With temperature of one electrode higher than the other there is an electrical flow between the electrodes. New approaches to the design of the electrodes and to the gas environment within the envelope have resulted in a more efficient flow of electrons than ever noted before.

Most previous methods of converting heat directly into electricity, according to General Electric's Dr. Volney C. Wilson, have been based on the thermocouple, but its efficiency is normally well below 1 per cent. Experimental converters already have shown an efficiency of more than 8 per cent; are hoped ultimately to show 30 per cent.

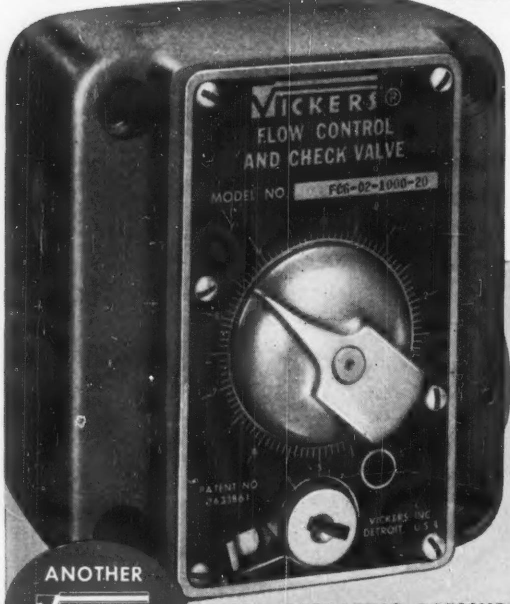


Experimental thermionic converter changes heat to electricity more efficiently than thermocouple. New device has shown 8 per cent efficiency, promises 30, as compared with less than 1 per cent for thermocouples.

Circle 414 on Page 19

ANNOUNCING!

VICKERS® New ¼″ Temperature and Pressure Compensated FLOW CONTROL VALVE



For years the Machine Tool Industry has been asking for a combination Temperature and Pressure Compensated Flow Control Valve to insure CONSTANT FEED RATES. Now for the first time it is available as a production unit at a reasonable price.

ANOTHER VICKERS FIRST

FOR OPERATING PRESSURES UP TO 2000 psi

Check THESE EXCLUSIVE FEATURES that mean Optimum Tool Life and Better Work Finish:

- **TEMPERATURE COMPENSATED**
  Constant feed rates all day long with same throttle setting because throttle automatically compensates for changes in oil temperature. The compensator mechanism is simple in design and durable.
- **PRESSURE COMPENSATED**
  Constant feed rate throughout entire cycle because built-in pressure hydrostat automatically compensates for load changes.
- **SINGLE THROTTLE COMPLETE RANGE ADJUSTMENT**
  Greater flexibility because valve is adjustable within entire flow range of 5 to 1000 cubic inches per minute.
- **REVERSE FREE FLOW AS STANDARD FEATURE**
  A standard feature which permits reverse free flow (up to 1400 cu. in. per min.) from outlet to inlet port by-passing control elements.
- **TAMPER-PROOF ADJUSTMENT**
  Retension of original feed rate is assured because a set screw prevents inadvertent throttle movement and a cover over the set screw can be locked in place.
- **INTERCHANGEABLE**
  This new valve replaces 12 previous models and it is interchangeable with all of them, also the drain connection is eliminated on the new valve to simplify piping.
- **GREATER ECONOMY**
  No need to stock several valves for wide range of flow rates. Drain connection is eliminated, piping costs are reduced.
- **MAXIMUM RELIABILITY AND ACCURACY**
  Design of temperature and pressure control components assures maximum circuit reliability and extreme accuracy of feed through a range of 5 to 1000 cubic inches per minute.

FOR ADDITIONAL INFORMATION SEND FOR I-195040

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

The French-built Facel-Vega Sports Coupe, one of two models available in the U. S., is powered by a 360-hp Chrysler Typhoon engine. Classified as a prestige car, this model will accelerate from 0 to 100 mph in 24 sec.

French-Built Luxury Car Features Chrysler Engine

NEW YORK — The French-made Facel-Vega, a recent entry in the U. S. prestige car market, combines a mass-produced American engine and transmission with a nearly hand-crafted European body and chassis. This astute combination makes spare engine parts and servicing readily available in this country.

The car is offered in two body styles; a two-door, four-seat Sports Coupe, powered by a 360-hp Chrysler Typhoon engine, and a four-door, five-passenger luxury model called the Excellence, powered by a 330-hp Typhoon engine.

Performance and comfort are emphasized. The car will accelerate from 0 to 100 mph in 24 sec. Power brakes, Chrysler pushbutton transmission, electrically controlled windows, and radio, heater, and defroster are standard equipment. Interiors are full leather with two separate seats and center arm rest in front.

Chassis by Facel is welded tubular steel; body is pressed steel and welded. Suspension system uses independent coil springs in front with normal half-elliptical springs at rear. Hydropneumatic shock absorbers are used at front and rear. Front brake drums are 11-in. aluminum, air cooled; rear drums are chromium-plated aluminum.

Dimensions

	Sports Coupe	Excellence
Wheelbase (in.)	104.7	124.8
Length (in.)	181.1	206.7
Width (in.)	70.8	72
Height (in.)	53	54.5
Weight (lb)	3885	4230

Hoffman Motor Car Co., distributes Facel-Vega in the eastern U. S.

Plastic Can Be Sterilized, Resists Solvents and Acids

Finds Application in Home, Pipe Fittings and Machines

NEW YORK—Resistance of a new thermoplastic to temperatures of more than 300 F permits sterilization of molded products. Called "Moplen," the material developed at Montecatini's Ferrara plant in Italy, is claimed to have excellent resistance to grease and oil, water, many common acids, and to have high impact strength.

Product of a new method of olefin synthesis, the plastic has unusual regularity of structure and controlled crystallinity. Control of crystallinity predetermines properties of the material, with higher degrees of crystallinity providing high strength, heat resistance, re-

sistance to solvents, and unusual electrical properties.

According to company spokesmen, the plastic will appear on the American market next year. It will be used for sterilizable household products, pipe and fittings, and textile machine parts.

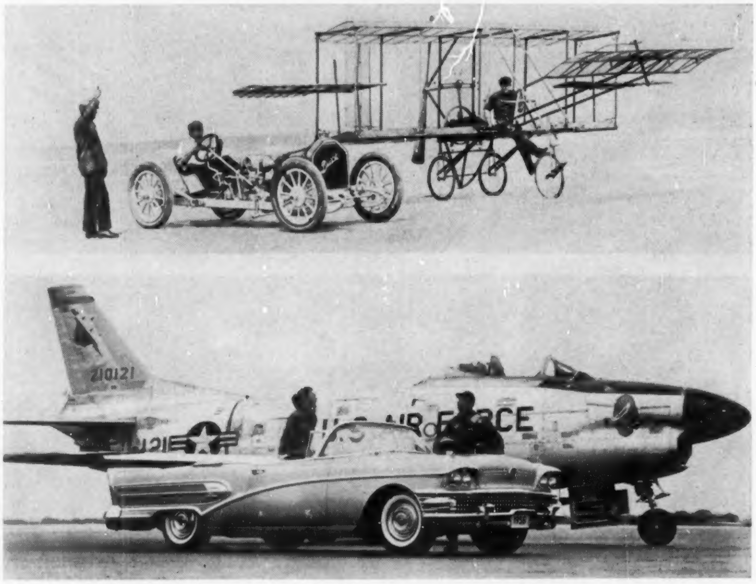
Bank Check Processing Speeded with Magnetic Ink

Once Magnetically Inscribed, Checks Handled Automatically

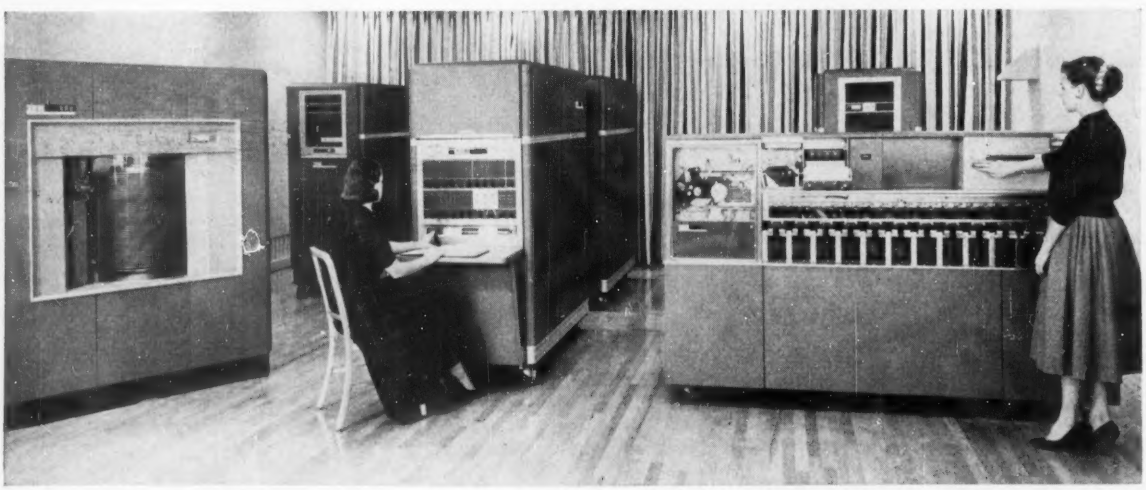
POUGHKEEPSIE, N. Y.—An electronic bank deposit system, designed around the use of magnetic ink identification, automatically processes intermixed checks in random sizes. At a recent special demonstration, the IBM Product Development Laboratory showed high-speed equipment which reads paper checks for sorting, posts them to an electronic ledger, and automatically prepares customers' statements from the checks.

The experimental equipment demonstrated reads a magnetic code on the top of the check, but will not be marketed. The market version of the equipment is planned to incorporate magnetic Arabic numerals on the bottom edge of the check, as recommended by the Technical Subcommittee of the American Bankers Association. The company is operating this equipment as a test and to gain systems experience.

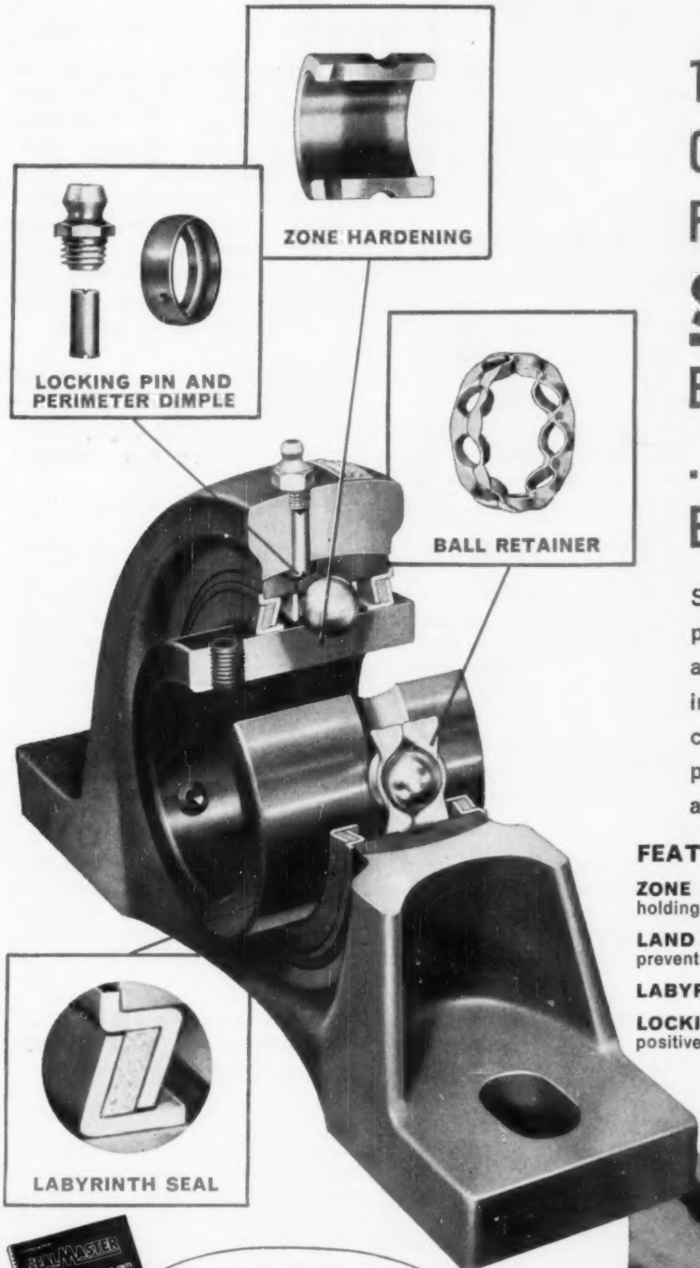
Demonstrated was a high-speed computer and a 6-million digit disc memory unit; also, two entirely new machines. One is an inscribing unit which, manually operated, keys identification and



FIFTY YEARS OF PROGRESS in American automotive and aviation design shows some promise despite foreign developments. Upper photo shows the start of a race between a stripped-down 1908 Buick and a late-model biplane of the same vintage. The Buick won. No race is contemplated with the F-86 in the lower picture, as progress has proven the sound barrier to be a lesser problem than traffic obstacles.



Experimental bank deposit equipment reads paper checks for sorting, posting, and automatic preparation of customers' statements. It includes a high-speed computer with an operator's central control console (center); a RAMAC random access disc memory unit (left) with a storage capacity to provide for 40,000 accounts; and a check sorting and reading machine (right). After checks are identified by magnetic ink inscription, the sorter-reader unit automatically sorts intermixed checks at speeds up to 900 checks per minute.



THIS EXCLUSIVE COMBINATION OF FEATURES IS YOURS WITH SEALMASTER BALL BEARING UNITS ...PLUS QUICK, EASY MOUNTING!

Slip a SEALMASTER Ball Bearing Unit into place on the shaft—tighten two set screws and you have the answer to ease of mounting in a bearing unit. SEALMASTER'S exclusive combination of features take over from there, providing smooth, trouble-free performance and long bearing life.

FEATURES:

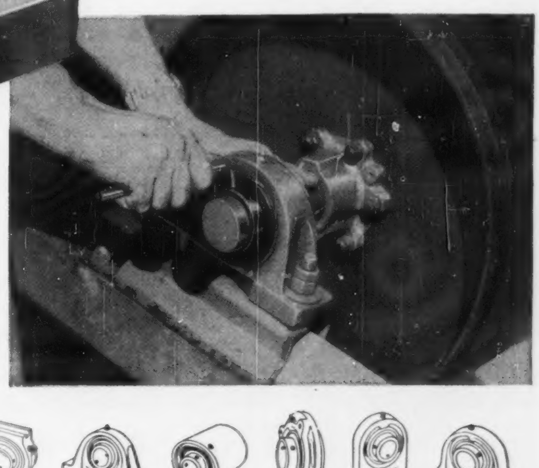
ZONE HARDENING . . . assures positive race-to-shaft holding power.

LAND RIDDEN BALL RETAINER . . . traps grease and prevents "churning."

LABYRINTH SEAL . . . keeps dust and dirt out, lubricant in.

LOCKING PIN & PERIMETER DIMPLE . . . assures positive lubrication.

Write for Bulletin 454 for full information.



SEALMASTER®

BALL BEARING UNITS

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO. 18 RIDGEWAY AVENUE, AURORA, ILL.

amounts on checks in magnetic ink. The other is a unit for sorting checks into desired sequence and reading them into the data processing system.

President's Committee Reports Its Action, Soviet Threat

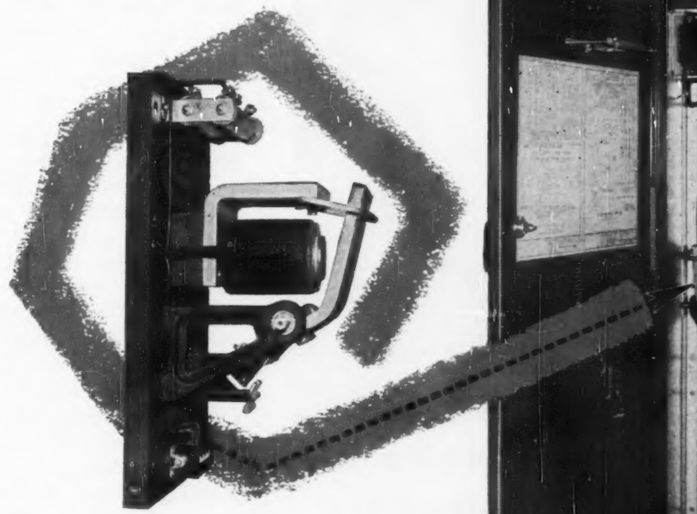
Suggest Soviet Advances Are More Than Military Challenge

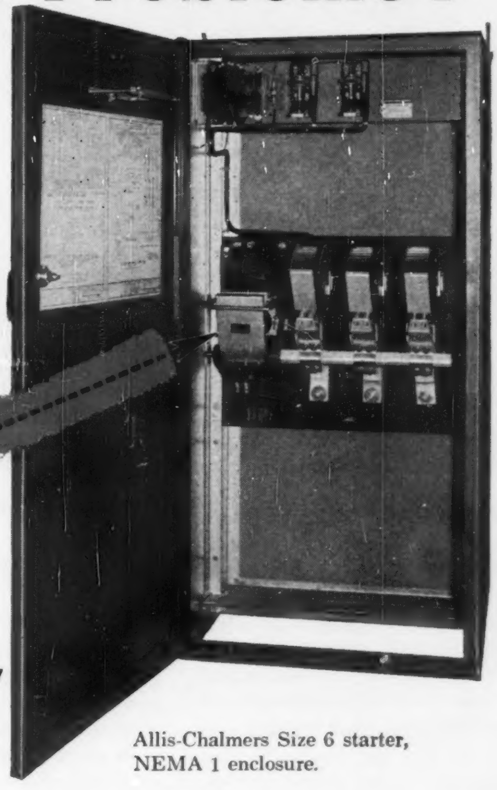
GETTYSBURG, PA.—The President's Committee on Scientists and Engineers has reported deep concern lest major American response to the Soviet challenge will be an all-out scientific effort to meet purely military needs; warns that Russian advances in other technological fields present an equally grave threat. Committee chairman Howard L. Bevis urges gathering of brainpower resources in company with other free nations, not only for defense, but to meet the broader challenges of science as well.

After 18 months of existence, the committee issued its second interim report. Summarized here are the committee's aims and its reported actions.

Aims	Action
Make full use of our scientists and engineers.	Is cosponsoring with local groups throughout the nation a series of 30 "utilization clinics." These clinics bring together engineers, scientists, industrialists and educators to develop and immediately use improved utilization practices.
Gather more adequate data on supply and demand of technical manpower.	Has joined the National Science Foundation and other organizations in a program to insure adequate statistical data.
Strengthen scientific and mathematics education in the elementary and secondary schools.	Is encouraging the organization of state and local groups—representing industry, labor, education, and the profession—to work together toward the long-range improvement of elementary and secondary school education with emphasis on science and mathematics.
Motivate greater numbers of our talented young people to enter science and engineering.	Will alert school staff guidance counselors to the future opportunities in science and engineering careers and make suitable counseling materials available.
Increase public understanding of the importance of an adequate supply of scientific manpower.	Is endeavoring to generate a public understanding of the vital need for highly qualified scientists, engineers, and supporting technicians; to achieve widespread recognition that the development of professional and skilled personnel rests largely upon the effectiveness of the educational system; and to encourage programs that will make clear to young people and parents the challenges and opportunities in scientific and engineering careers. The local action program is designed to reach students and their parents directly through committee publications, press and radio-TV publicity, and the work of local action groups.
Encourage the training and use of technicians to release scarce professionals from routine duties.	Encourages reorienting our system of higher education to give more weight and emphasis to two-year courses leading to a diploma or other suitable award. The committee also believes that a wider public appreciation of the important role which can be played by technical institutions of intermediate level and the establishment of more of these institutions would do much to help solve the too-long-neglected need for a greater number of technicians.

Dirt, Corrosion, Low Voltage Problems?





the answer:

Allis-Chalmers "dc operated" ac contactors*

Allis-Chalmers Size 6 starter, NEMA 1 enclosure.

Dc operators in Allis-Chalmers control assure dependable performance because they are not affected by dirt or corrosion on the armature face. Positive magnetic operation reduces contact pitting — eliminates hum and chatter—prolongs mechanical life. The operator picks up at 65% of rated voltage — holds in with as little as 35%.

For Any Low Voltage, High Horsepower Application . . . Allis-Chalmers Modern Control — Sizes 4, 5 and 6

Advanced Electrical Design
ACBO arc-centering blowout sharply curtails arcing time, greatly prolongs contact and chute life — without blowout coils.

Simplified Mechanical Design
Streamlined clapper-type construction permits natural arc rise in arc chute. Sensible enclosure dimensions provide ample wiring space. Easy accessibility simplifies maintenance.

For detailed information on this complete line of modern control, call your A-C Control Distributor or A-C District Office. Or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

*Self-contained ac to dc circuit. Standard in Size 6, optional in sizes 4 and 5.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A5372

ACBO is an Allis-Chalmers trademark.

Circle 419 on Page 19

News Roundup

Industry in New Age, Must Stress Quality

99.44% Reliability of Parts Would Mean Failed Missile

NEW YORK—The U. S. is playing, or should be playing, an entirely new ballgame. As the size of things go up, the little things actually become more important. In the Atlas missile, reputed to have 300,000 separate components, each part must have a reliability for the mission of 99.99996% to be on target 9 times out of 10. If Atlas' 300,000 parts each had a reliability of only 99.44%, they would never get a single one to its destination.

"Just when mistakes are becoming more costly, they are also becoming much more likely. That's the result of an increasing complexity of design, a growing number of parts, a multiplying quantity of mechanical and electrical, pneumatic, hydraulic, and electronic components." So spoke H. Thomas Hallowell Jr., president of Standard Pressed Steel Co., to more than 500 members at an American Management Association conference on quality control.

One of the fundamental obstacles to hurdle in this country, he said, is the fact that too much of our American production-line thinking is being used at a time that calls for more "missile age thinking." He defined missile age thinking as the realization that all the parts must work, no matter how seemingly insignificant any one part may seem.

"Reliability," he said, "is not just the province of the missile makers — it's much more widespread in its importance. It is daily becoming more critical in all phases of production and product design and it affects every one of us."

He pointed to highway safety where, despite more horsepower, more cars, and not enough roads, we still every year have faster, longer, and wider cars and trucks, about 50 million in service today. Then he assumed 100 critical mechanical joints on each and translated these as 5 billion potential sources of failure.

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News Roundup

Discussing a recent survey in New Jersey that traced more than 1200 crashes to fasteners, he said that the loosening of threaded fasteners in such places as brakes, frames, wheels, axles, front ends, and steering mechanisms must be expected. The facts lead to an obvious conclusion, he told the assembly. "That is the urgent need for more quality, more reliability."

Even the consumer goods field is pressed for high orders of reliability. Hallowell referred to the rising cost of labor which is putting the burden on the appliance maker to produce foolproof merchandise or lose business. "The public is becoming aroused," he added, referring to loosened doorknobs, broken washing machines and "those excruciatingly diabolical little eyeglass screws that keep coming out at the wrong time."

"Automation certainly demands increased reliability," he said. "As we string more and more machines together in an automated plant, more likelihood of breakdowns automatically follows . . ."

He called miniaturization "That irrepressible need to do more with less . . . When we're miniaturizing, in most cases, we're simply cutting down on the factors of safety, the margins for error." He said that increased reliability, despite miniaturization, is available through increased knowledge of product performance under working conditions. In the aviation industry, he cited designs in some areas with a margin of only 15 per cent where other industries are still using safety factors of 800 and 1000 per cent.

"Reliability," concluded Hallowell, "is no ivory-tower speculation—it's a matter of staying in business—either as a nation or as an industrial enterprise."

Ceramic-Envelope Electron Tubes Designed to Meet Military Needs

HARRISON, N. J.—Development of very small ceramic-envelope electron tubes for special military requirements is under way at RCA's Electron Tube Division. According to RCA, "the tubes will be

Circle 421 on Page 19

capable of operating at high frequencies, high ambient temperatures, and in the presence of nuclear radiation. As a result of their unique ceramic-envelope construction, they will withstand high shock, severe vibration, and will have extremely long life. In addition, construction of the tubes permits manufacture by mass production techniques.

Exceptionally small and lightweight, the ceramic-envelope tubes employ a cylindrical, coaxial element structure, supported in a cantilever fashion—a design feature that is said to result in excellent electrical performance.

Meetings

AND EXPOSITIONS

Jan. 13-17—
Society of Automotive Engineers Inc. Annual Meeting and Engineering Display to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Jan. 27-30—
Plant Maintenance and Engineering Show and Conference to be held at the International Amphitheatre, Chicago. Additional information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 28-31—
Institute of the Aeronautical Sciences. 25th Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Feb. 2-7—
American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Additional information can be obtained from institute headquarters, 33 W. 39th St., New York 18, N. Y.

(*Please turn to Page* 36)

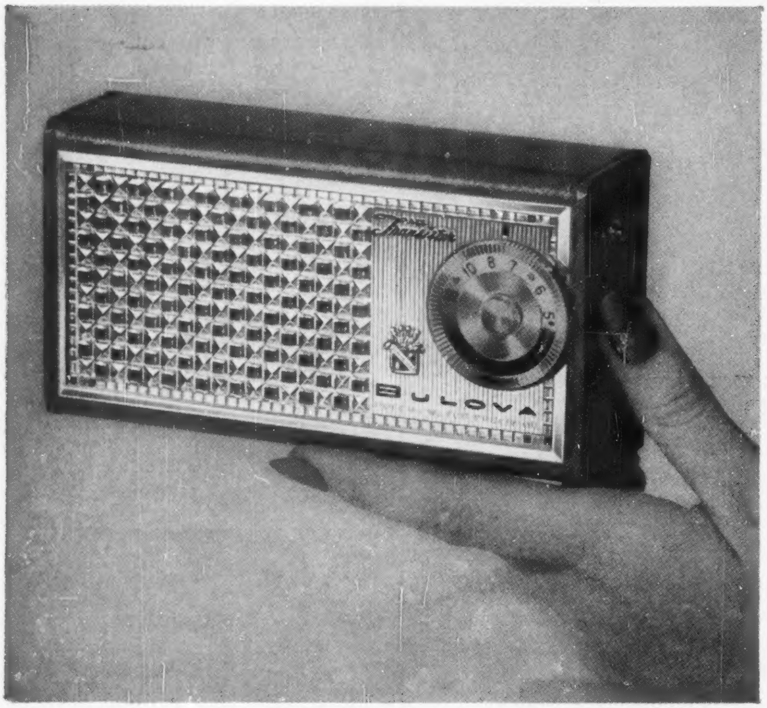
DU PONT

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

PRODUCT

LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS

Intricately-molded face plate of LUCITE® 140 adds to overall beauty of transistor radio



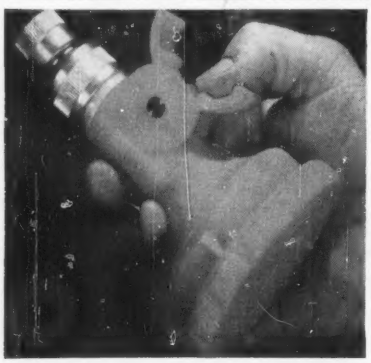
REVERSE-SURFACE decorated face plate of transistor radio is typical of the intricate, yet durable, molded pieces possible with improved formulation of Du Pont LUCITE 140 acrylic resin. (The above face plate is molded and decorated by Kent Plastics, Evansville, Indiana, for Bulova Watch Company, Flushing, New York.)

An improved formulation, LUCITE 140, is behind the intricate beauty of the face plate on the new Bulova transistor radio. The attractive piece, reverse-surface decorated in a golden color, has the added advantages of excellent durability and high impact strength.

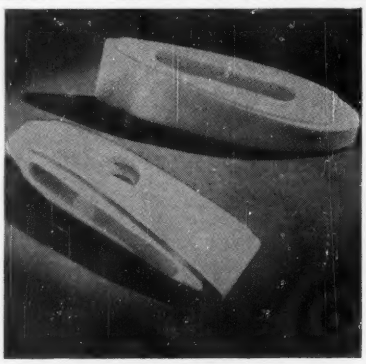
LUCITE 140 permits molding temperatures considerably higher than was previously possible, resulting in increased fluidity during processing and increased stability in the finished part. Injection time is shorter, smaller gates are used, and consequently, trimming is reduced. The result is more intricate shapes, easily produced, and often at an increase in top service temperature.

LUCITE acrylic resin can also be readily and economically fabricated to close tolerances by compression molding and extrusion. It is easily formed with conventional woodworking tools, much like wood or metal.

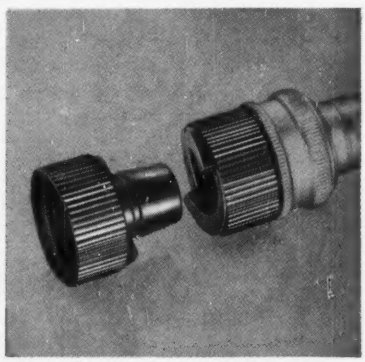
If you would like more information on this outstanding material, just mail the coupon on the next page.



"PERMA-JET" showerhead case and major operating parts of Du Pont ZYTEL are durable and heat-resistant. ZYTEL resists chemicals and corrosion, prevents clogging, keeps water rust-free. Water distribution is even, force of spray can be easily adjusted as desired. (Made by Webb Industries, Bay Village, Ohio.)



AIRCRAFT ANTENNA insulator block of a Du Pont TEFLON tetrafluoroethylene resin isolates antenna from metal base. High-density, stress-free block withstands air flow strains and minimizes dimensional change created by temperature extremes. (Mfgd. by John L. Doré Co., Houston, Texas.)



BLACK ZYTEL 105-BK10 is used for this garden hose coupler which connects with a simple push, twist to disconnect. The rugged coupling survives shock and abrasion. It will not corrode, even in the presence of garden chemicals. (Molded by The Ark Inc., for Stile Craft Mfg. Co., both of St. Louis, Mo.)

News Roundup

(Continued from Page 33)

Feb. 4-6—
Society of the Plastics Industry Inc. 13th Annual Technical and Management Conference of the Reinforced Plastics Div. to be held at the Edgewater Beach Hotel, Chicago. More information is available from society headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 13-15—
National Society of Professional Engineers. Spring Meeting to be held at Michigan State University, East Lansing, Mich. Further information is available from NSPE headquarters, 2029 K St. N. W., Washington 6, D. C.

March 3-6—
American Society of Mechanical Engineers. Gas Turbine Power Div. conference and exhibit to be held at the Shoreham Hotel, Washington, D. C. Further information is available from Mr. Barry Freer, 1300 Connecticut Ave. N. W., Washington 6, D. C.

March 4-6—
Society of Automotive Engineers Inc. Passenger Car, Body and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 11-14—
Pressed Metal Institute. Spring Technical Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

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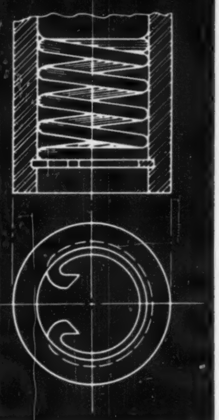
MEMO TO ENGINEERS—

Simplify your designs with –

NATIONAL RETAINING RINGS

Request Catalogs Today—

or ask a NATIONAL Sales Engineer to give you the facts on your particular design application at your convenience.



...eliminate costly shoulders
...groove smaller shafts and housings

Installing NATIONAL Retaining Rings in simple grooves permits the use of smaller shafts and housings . . . saves machining and material wasted when larger shafts are cut down to make shoulders. Thousands of performance-proven applications include heavy machinery, engines, drill presses, tools, toys . . . products of metal, plastics and wood. Simplify the design of your products by utilizing the high efficiency of these easily installed NATIONAL Retaining Rings. Save weight, space, material, production and assembly time!

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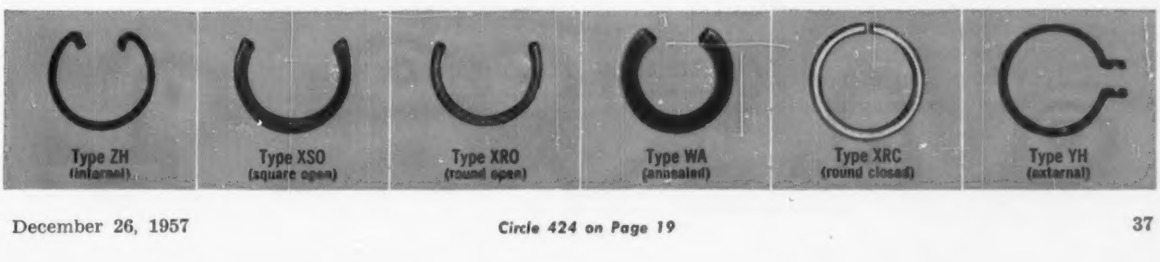


Circle 425 on Page 19

Here's a whole new family of fine GEARMOTORS by Cone-Drive Gears

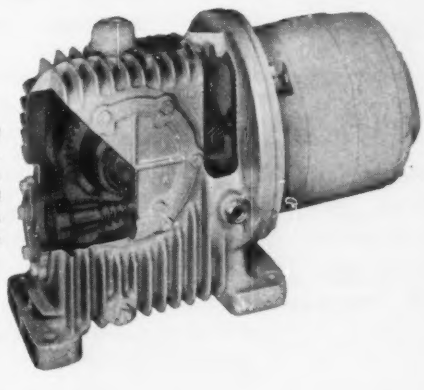
MOUNT THEM ANYWHERE— FLOOR, WALL, CEILING, OR HANG THEM ON A SHAFT...

. . . there's a Cone-Drive gearmotor for every need. Look at the extensive line of space-saving, power-packed models now available. No matter whether you're faced with floor, wall, ceiling, or shaft mounting at any angle, Cone-Drive Gears has a gearmotor for the job.

It's the most versatile line available PLUS big power capacity in a really compact package. Double-enveloping worm gears, pioneered and proven by Cone-Drive Gears, are combined with a helical primary and extra-large taper roller bearings in a rugged finned housing to give you a power package without equal. You can select any model in any of 27 standard output speeds (7.3 to 525 rpm at 1750 rpm input) in capacities from 1 through 25 horsepower.

Best of all, Cone-Drive gearmotors are priced right down with units that can't deliver nearly as much performance and versatility. Check your nearby Cone-Drive representative or write today for new Catalog 57 containing complete specifications.

Cutaway view of typical Cone-Drive gearmotor illustrates use of double-reduction gear train for increased output power. Note also large taper roller bearings and heavy-ribbed housing.



CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division, Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

Circle 426 on Page 19

Now! A Complete Line of Self-Locking Microsize UNBRAKO Socket Cap and Set Screws

Nos. 0, 1, 2 and 3 in alloy steel and stainless steel are available with the Nylok* feature

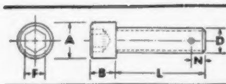
You effect major economies in time and money when you design and assemble small devices with self-locking microsize UNBRAKO socket screws. These close tolerance screws won't work loose. They simplify standardization of small devices where maximum reduction of weight is required without sacrifice of strength. They eliminate the necessity of designing costly special screws to fasten tiny parts in compact assemblies and they prevent the waste of production time while waiting for delivery of special screws.

In addition to having the overall advantages of microsize UNBRAKO socket screws, these screws can be used in holes tapped in soft or die cast materials without stripping threads and ruining expensive work. Also the set screws can be used with hardened shafts, since they lock against the threads of the tapped hole.

All UNBRAKO socket screws can be supplied with the self-locking Nylok feature. The UNBRAKO with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Seated or not, the screw locks positively wherever wrenching stops, won't work loose—because the tough resilient nylon pellet forces mating threads together.

Ask your authorized industrial distributor for details today. He carries complete stocks of self-locking UNBRAKO socket screws (caps and sets from #0 through 1 in., button heads #4 through ⅝ in., flat heads from #4 through ¾ in.). Or write us for literature and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

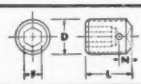
*T.M. Reg. U.S. Pat. Off., The Nylok Corporation



HEAT-TREATED ALLOY STEEL
Self-Locking Microsize UNBRAKO
Socket Cap Screws
Class 3A Threads

Screw Size		Threads per in.		L Over-all Length	N Pellet Location		Torque		
		NC	NF		NC	NF	Max. prev. on	1st off stat. min.	5th off stat. min.
#0	A .104	—	80	⅛	—	.047	5.5	14.0★	7.0★
	B .060	—	80	3/16	—	.047	5.5	14.0★	7.0★
	D .060	—	80	¼	—	.047	5.5	14.0★	7.0★
	F .050	—	80	⅜	—	.047	5.5	14.0★	7.0★
#1	A .118	—	72	⅛	—	.047	11.0	28.0★	14.0★
	B .073	—	72	3/16	—	.047	11.0	28.0★	14.0★
	D .073	—	72	¼	—	.047	11.0	28.0★	14.0★
	F .050	—	72	⅜	—	.047	11.0	28.0★	14.0★
#2	A .140	56	—	3/16	.063	—	24.0	3.0	1.5
	B .086	56	—	¼	.063	—	24.0	3.0	1.5
	D .086	56	—	⅜	.063	—	24.0	3.0	1.5
	F 1/16	56	—	½	.063	—	24.0	3.0	1.5
#3	A .161	48	—	3/16	.063	—	40.0	6.5	3.0
	B .099	48	—	¼	.063	—	40.0	6.5	3.0
	D .099	48	—	⅜	.063	—	40.0	6.5	3.0
	F 5/64	48	—	½	.063	—	40.0	6.5	3.0

★Measured in in.-gm. (those not marked with a star are measured in in.-oz.)



HEAT-TREATED ALLOY STEEL
Self-Locking Microsize UNBRAKO
Socket Set Screws
Class 3A Threads

Screw Size		Threads per in.		L Over-all Length	N Pellet Location		Torque		
		NC	NF		NC	NF	Max. prev. on	1st off stat. min.	5th off stat. min.
#0	D .060 F .028	—	80	3/32	—	.047	5.5	14.0★	7.0★
		—	80	⅛	—	.047	5.5	14.0★	7.0★
		—	80	5/32	—	.047	5.5	14.0★	7.0★
		—	80	3/16	—	.047	5.5	14.0★	7.0★
		—	80	¼	—	.047	5.5	14.0★	7.0★
#1	D .073 F .035	—	72	⅛	—	.062	11.0	28.0★	14.0★
		—	72	5/32	—	.062	11.0	28.0★	14.0★
		—	72	3/16	—	.062	11.0	28.0★	14.0★
		—	72	¼	—	.062	11.0	28.0★	14.0★
#2	D .086 F .035	56	—	⅛	.062	—	24.0	3.0	1.5
		56	—	5/32	.062	—	24.0	3.0	1.5
		56	—	3/16	.062	—	24.0	3.0	1.5
		56	—	¼	.062	—	24.0	3.0	1.5
#3	D .099 F .050	48	—	5/32	.093	—	40.0	6.5	3.0
		48	—	3/16	.093	—	40.0	6.5	3.0
		48	—	¼	.093	—	40.0	6.5	3.0

★Measured in in.-gm. (those not marked with a star are measured in in.-oz.)

Self-locking microsize UNBRAKO socket cap and set screws are available in sizes #0 through #3, in heat treated alloy steel (plated or unplated) and stainless steel, at your authorized industrial distributor. He also carries a complete stock of other self-locking UNBRAKO socket screws.

We also manufacture precision titanium fasteners. Write for free booklet.

SPS

Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co., Inc. • Cooper Precision Products • Standco Canada Ltd. Unbrako Socket Screw Co., Ltd.

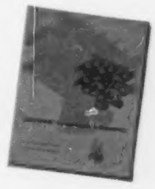
Circle 427 on Page 19

HAYNES Investment-Casting Solves the *tough* design problems

INTRICATE DESIGNS
Mass-Produced Economically
...by Investment-Casting

Intricate shapes in hard-to-machine metals . . . sound metallurgical structures . . . close as-cast tolerances . . . smooth surfaces . . . are all available on a mass-production basis through HAYNES' investment-casting process. This modern mass-production method enables the design engineer to select the best alloy and most efficient design for an application. Desired parts can be made to specifications economically, regardless of how difficult or costly they might be to produce by other methods.

Haynes Stellite Company's extensive services and experience . . . complete tooling, production, quality control, metallurgical, and finishing facilities . . . plus a staff of more than 200 craftsmen . . . plus a selection of more than 25 alloys . . . guarantees that here you will obtain all the benefits the process has to offer.



For complete details, ask for our 40-page book. Write to HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, Literature Section, 30-20 Thomson Ave., Long Island City, N.Y.

Inspecting Castings—Every casting is carefully inspected to insure top quality. "Zyglo," gamma ray, x-ray, and hundreds of precision gages are available to make sure parts meet specifications.

HAYNES
ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

 Circle 429 on Page 19

 Circle 430 on Page 19

PROBLEM:

How to get <u>extra</u> wear resistance high core strength <u>and</u> good toughness in impact mechanism of new power hammer

SOLUTION: Nickel alloy steel—<u>Carburize</u>!

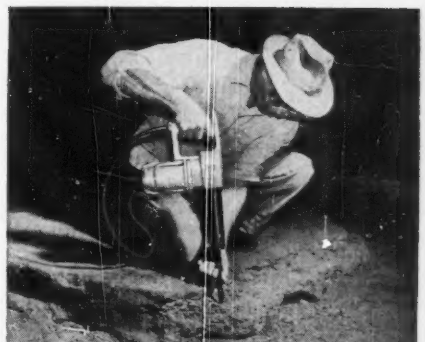
The parts shown in section above are the heart of the impact mechanism of Ingersoll-Rand's new lightweight electric power hammer.

They're made of 8640, a nickel alloy steel. By carburizing the parts, I-R gets a surface with extra wear resistance while retaining the very high strength of the fully hardened core to take the impact and stress of 2300 blows a minute.

Piston, crosshead and both outer and inner spring seats are made this way. They can withstand terrific, continuous pounding and shock load *with a minimum of wear . . . without deforming or cracking.*

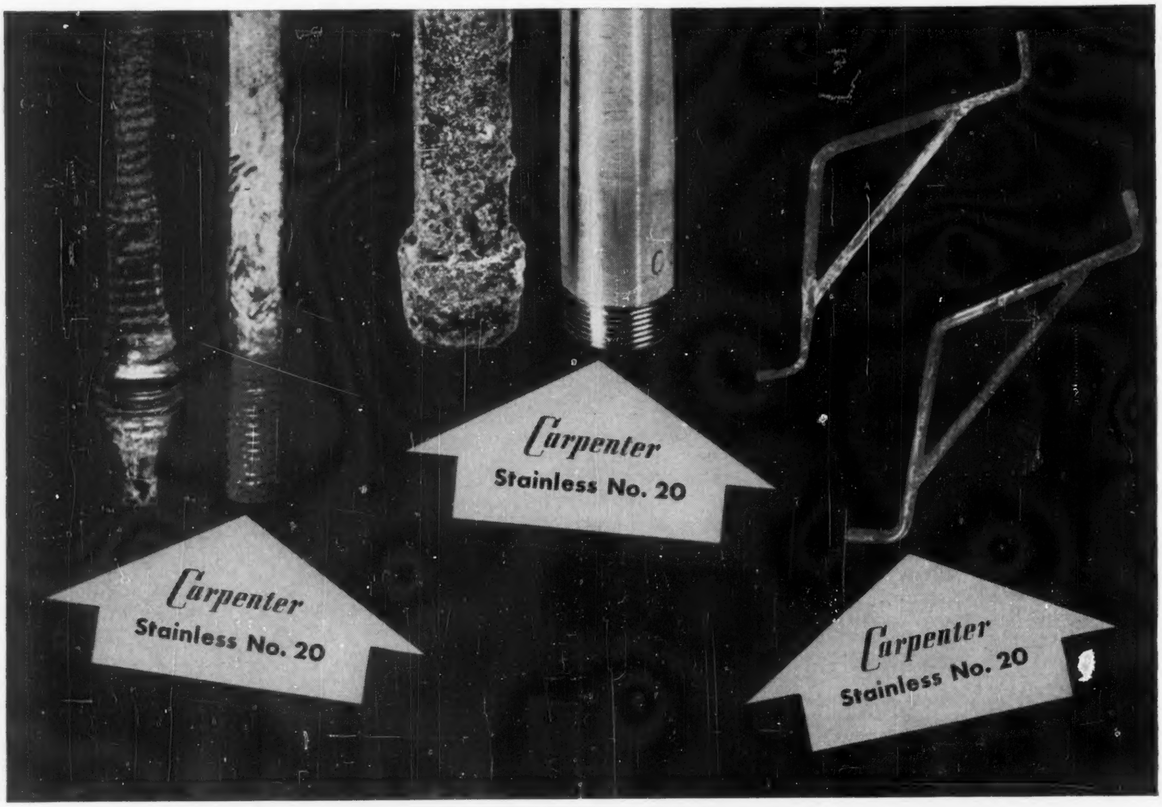
Your requirements may be altogether different from Ingersoll-Rand's. But when you need a metal with the "extra" properties there's a grade of nickel alloy steel to cover practically every fabricating or service demand.

Send us details of your application and we'll be happy to help you.



New electric power hammer by Ingersoll-Rand, New York, N. Y., can be used for breaking concrete (above), stone, macadam . . . for drilling, roughing, cleaning, caulking, scaling, chipping, seaming and dozens of other jobs. Unit weighs only 12 lbs. and features an exclusive "spring floating" piston.

INCO **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.



How to add months – even years . . . to equipment exposed to severe corrodents

All six of the items pictured above, the nozzles, rod, and hangers, have seen tough service in H_2SO_4. Only three were made from Carpenter Stainless No. 20. The users are still not sure just how much Stainless No. 20 is going to save them, because when the field reports came in, each item was still in use!

Super corrosion resistance can be a big help in bolstering your profit picture by cutting down on waste. Industries concerned with corrosion report that losses usually run as high as 25% of total profits.

Don't design these losses into your operation. When you design parts or pieces of equipment, consider the economy of Carpenter Stainless No. 20 for applications where sulphuric acid and other severe corrodents are used.

Call your Carpenter Mill-Branch Warehouse, Office or Distributor . . . or write direct for full information.

Carpenter Stainless No. 20 and No. 20-Cb are available in the forms of bars, wire, strip and billets from The Carpenter Steel Company, Reading, Pa. Carpenter Stainless No. 20-Cb is available from the Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, bars, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire. Available from our Webb Wire Division, New Brunswick, New Jersey, are Stainless No. 20 and No. 20-Cb in fine wire sizes.

Carpenter STEEL

Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels through Continuing Research

The Carpenter Steel Company, 120 W. Bern St., Reading, Pa.

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Circle 431 on Page 19

NOW!

WHETHER YOU WANT TO MOVE 2 POUNDS 2 INCHES, OR 10 TONS 10 FEET—FORGET ACME SCREWS, HYDRAULICS, PNEUMATICS, CABLES AND PULLEYS

THE HIGH-PERFORMANCE LOW-COST ACTUATOR FOR VOLUME PRODUCTS

You can Actuate it Smoother, Simpler, Surer, Speedier and Usually Cheaper with the World's Most Efficient Roto-Linear Device

TYPICAL APPLICATIONS

- Automatic Garage Doors
- Automobile Seat Adjusters and Window Lifts
- Barber and Beauty Chairs
- Bumper Jacks
- Circuit Breakers
- Convertible Top Lifts
- Die Table Positioners
- Drill Presses
- Hospital Beds
- Lifters and Lift Trucks (Lift Tables)
- Marine Steering Gears
- Welding Machines

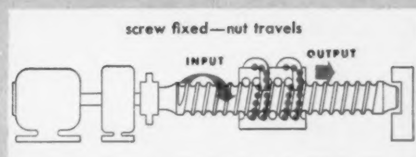
7 STANDARD SIZES

Ball Circle Diameter	Ball Size	Lead	Attaching "V" Thread Size
.375	.0625	.125	.664-32
.631 (R & L)	.125	.200	15/16"-16
1.000	.15625	.250	1.563-18
1.171	.28125	.41304	1.967-18
1.500	.34375	.47368	2.548-18
2.250	.375	.500	3.137-12
3.000	.500	.660	4.325-12

FREE ENGINEERING HELP

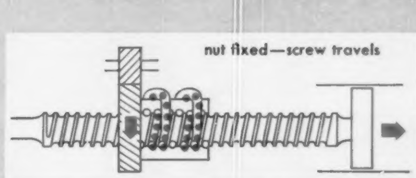
If you are currently using some other method of actuation—or think that the b/b Screw could improve the performance and sales appeal of your product, but are not sure how to apply it—let's get our heads together. Experienced Saginaw engineers, who have solved thousands of actuation problems, are at your service without obligation. Just write or phone us your requirements—or fill in and mail the handy coupon below.

BETTER ACTUATION with LOW POWER, LOW COST!



FORWARD: When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

FORWARD: When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



GIVE YOUR PRODUCT THESE PROFIT-BUILDING PRODUCTION AND SALES ADVANTAGES:

1. With friction almost eliminated, the b/b Screw has a guaranteed minimum efficiency of 90%—performs up to 6 times better than acme screws.
2. Because of its far greater efficiency, the b/b Screw requires far less torque—saves up to 85% on operating power or manual effort.
3. The b/b Screw is smaller and lighter than comparable units; permits smaller motors and gear boxes; often eliminates clumsy auxiliary parts.
4. Smooth, almost frictionless operation assures long, troublefree b/b Screw life . . . even in extreme temperatures and with lack of lube!

Saginaw b/b Screw

ROLLED THREAD

WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE!

SEND TODAY FOR THIS FREE 1958 ENGINEERING DATA BOOK . . .

or see our section in Sweet's Product Design File

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 11MD, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME ____________________

COMPANY ____________________ TITLE ____________________

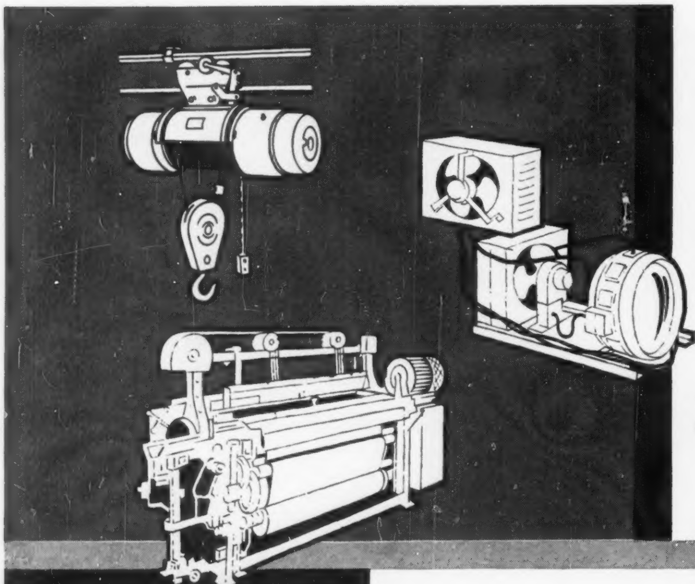
ADDRESS ____________________

CITY ____________ ZONE ______ STATE ____________

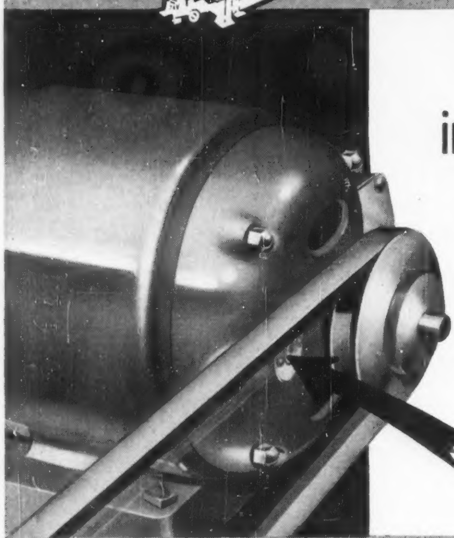
SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN

WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

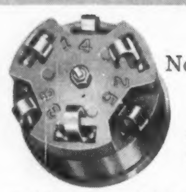
Circle 432 on Page 19



Whatever You Manufacture...



in all types of motor-driven equipment your 3-phase motors can be **protected against burnout** — with built-in KLIXON Protectors



Now your 3-phase motors can have the same engineered protection that motor manufacturers have supplied for years in single phase motors. That's because more and more motor manufacturers are making available 3-phase motors with built-in KLIXON Protectors.

You can get this protection against costly burnouts — protection that means maximum work output and minimum down time — in your 3-phase motors from fractionals up through 7½ HP (600V).

Get the details from your motor supplier . . . then specify and use motors with KLIXON Protectors. The additional cost is small, the savings worthwhile.

Built-in KLIXON Automatic and Manual Reset Protectors for single and 3-phase motors:

- Reduce production down time
- Eliminate motor burnouts
- Minimize motor repairs and replacements
- Assure maximum motor capacity
- Simplify motor controls

METALS & CONTROLS CORPORATION

Spencer Thermostat Division 3212 Forest Street, Attleboro, Mass.

KLIXON®

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RX *MIXED-FLOW BLOWER UNIT: A TORRINGTON 1st*

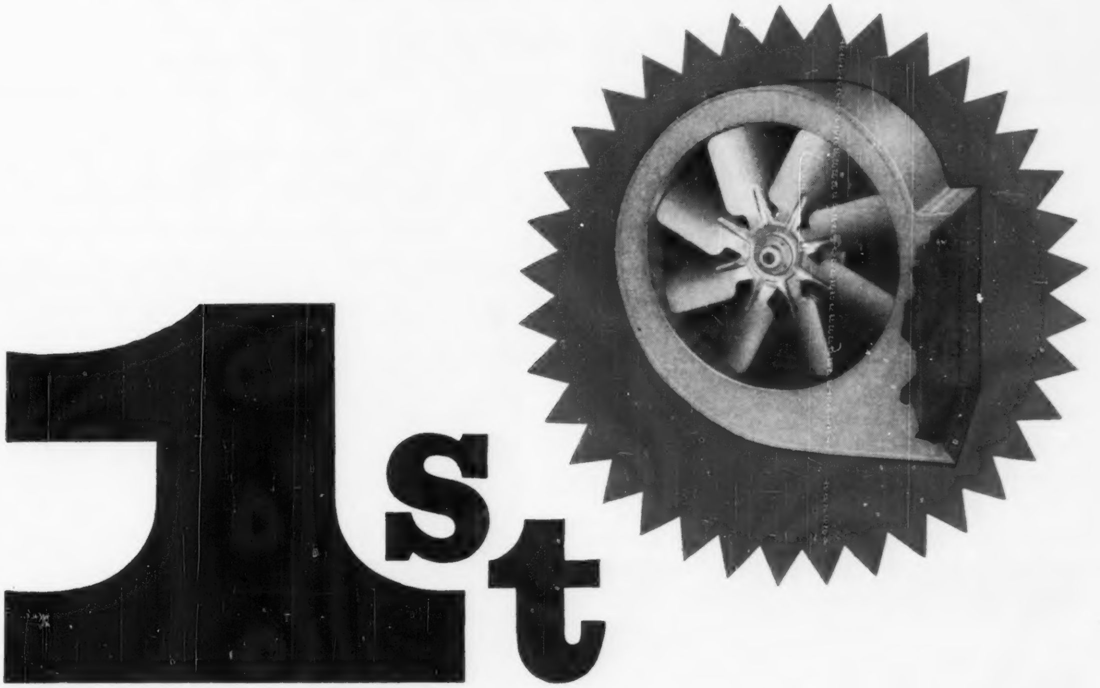
The Torrington RX Radiax blower introduces a new development in air impeller engineering.

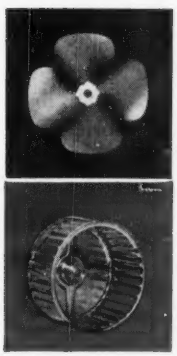
It is a direct drive mixed-flow unit employing an exclusive Torrington design concept which results in the conversion of axially-developed air pressure into a radial flow pattern.

The result of this design breakthrough is a versatile unit that can be tailored to an extended range of customer needs by modification of the axial fan configuration to exact performance specifications. This eliminates dependence upon a variety of different sized units for varying requirements.

The RX offers three important advantages:

PERFORMANCE—A flat power curve makes it a non-overloading unit, permitting the use of a single smaller-capacity motor for varying applications, and availability of the unit in sizes heretofore too large for direct drive applications.





CONSTRUCTION—A vertical center panel divides the unit longitudinally and supports the motor at its center of gravity. Resilient motor and fan mountings minimize noise and vibration. Result is quiet performance, and easy assembly and service.

ECONOMY—The basic design permits size reductions of as much as 36 per cent in the cubic dimensions of the unit, without sacrifice of performance. Thus, the RX is a thinner, more compact unit that can be fitted into tighter areas without choking of air intakes.

The design and performance of the RX give it a versatility that is of special importance to design engineers of air moving equipment. Full specifications are available.

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

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News about HYPALON®

Gaskets of HYPALON unaffected by 2% ozone after two years' use

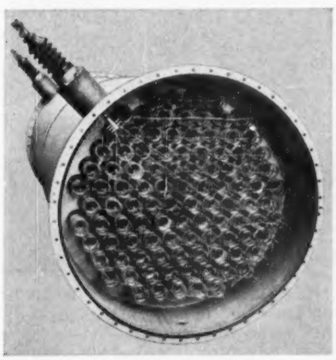
For two years, a large chemical firm has used gaskets of HYPALON in its ozone generators. Despite constant exposure to 2% ozone, not one gasket failed because of ozone cracking.

The ozonator is a steel shell packed with glass tubes. As dry oxygen passes through the tubes, it is converted to ozone by high-voltage electrical discharge. Each end of the shell is closed by a dished head sealed with a gasket of HYPALON.

Plastic gaskets too rigid

Plastic gaskets, which were formerly used in the generators, were unaffected by ozone, but took a permanent set under flange pressure. When a head was removed for routine maintenance the plastic gasket was too distorted to put back. Gaskets of HYPALON are reused.

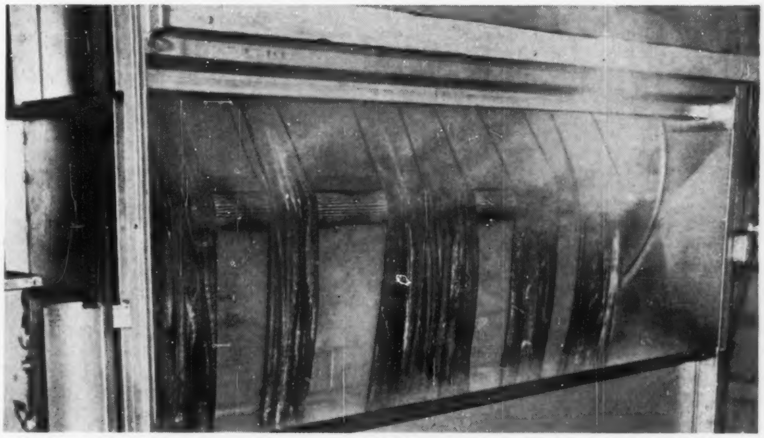
HYPALON offers many additional advantages compared to other types of rubber. It resists strong oxidizing acids; can operate at temperatures from 250° F. to 350° F.; resists weather and sunlight. This Du Pont synthetic rubber can also be compounded in an unlimited range of stable colors. HYPALON offers extra long life and lower operating costs in jobs where conditions are severe. Mail coupon for full information.



Gaskets made of HYPALON seal each end of this ozonator; they show no deterioration after two years in service.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

"Non-skid" neoprene reels help dye slippery synthetic fabrics



Fluted neoprene bars show little wear after four years in dye machine. Dye bath may be acid or alkaline, oxidizing or reducing. Temperature is 200° F.

Mill uses neoprene to get needed traction for hauling fabric through dye bath

Chatham Manufacturing Co., of Elkin, N. C., used neoprene to solve an unusual problem in dyeing synthetic fibers. Long loops of the fabrics are dyed in stainless steel piece dyeing machines. Loops, often 100' long, are pulled through the dye bath by means of a reel. The slow rotation of the reel assures even dyeing over the full length of the goods.

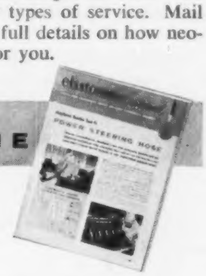
The progress of the fabric depends entirely on friction between reel and loop. When several types of metal reels failed to produce enough friction to pull the smooth synthetic fabrics through the bath, Chatham designed special fluted neoprene bars for the reels. They provided adequate traction and ended the problem of slippage and uneven dyeing.

Chemical resistance important

Bars covered with natural rubber could have solved the traction problem but neoprene was chosen for its excellent chemical resistance. In dyeing various fabrics the dye bath may be acid or alkaline, oxidizing or reducing. Each dyeing cycle requires 3-5 hours at 200° F., and the dye machines operate 24 hours a day. Ordinary rubber just couldn't stand this treatment. Chatham's Superintendent of Dyeing, Mr. V. Caton, reports that neoprene has given excellent service for four years with little wear.

Neoprene's resistance to chemicals, heat and abrasion means long-term wear—and economy in many types of service. Mail coupon below for full details on how neoprene can work for you.

ELASTOMERS IN ACTION HYPALON® • NEOPRENE



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REG. U.S. PAT. OFF.

Better Things for Better Living ... *through Chemistry*

☐ I am particularly interested in ____________

☐ Please add my name to the mailing list for your free publication, the ELASTOMERS NOTEBOOK.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-12
Wilmington 98, Delaware

Name ____________
Firm ____________
Address ____________
City ____________ State ____________

Circle 441 on Page 19

Does your present source have an ax to grind in favor of one or two basic power transmission drives?

Only Morse offers all four of these basic drives, plus a complete line of power transmission products

Basic Drives: Roller Chain, Silent Chain, Hy-Vo® Drives, and "Timing"® Belt.

Chain: High-Endurance (H-E), 8-series (Super Strength), Double-Pitch, Conveyor, Implement, and Attachment; AL, BL, Cable Chain, and Rollerless Lift Chain; Industrial Standard and 3/16" Silent Chain.

Stock Sprockets: Plain Bore, Finished Bore, Taper-Lock—also made to order.

"Timing" Belt Sprockets: Plain Bore, Taper-Lock, Q.D.—also made to order.

Couplings: Flexible Roller Chain Couplings, Flexible Silent Chain Couplings, Morflex Couplings, Morflex Radial Couplings, and Marine Couplings.

Driveshafts: Morflex and Radial Driveshafts.

Clutches: Cam (Over-Running, Back-Stopping, Indexing); Pullmore; Over-Center, Centrifugal.

Speed Reducers: Eberhardt-Denver "RW" poweRgear® Reducers; Gear Motors; "L" Worm Gear Reducers; "VX" and "DVX" Conveyor Drives; Miter Boxes; Helical Reducers.

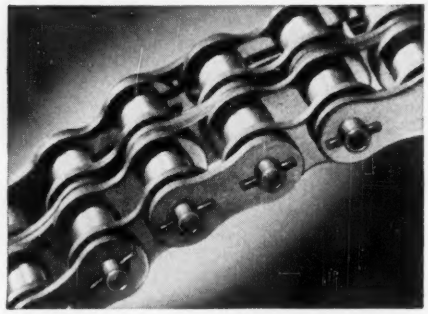
Torque Limiters.

Look for your local Morse distributor in the Yellow Pages under "Power Transmission," or write: *MORSE CHAIN COMPANY, DEPT. 6-127, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois.*

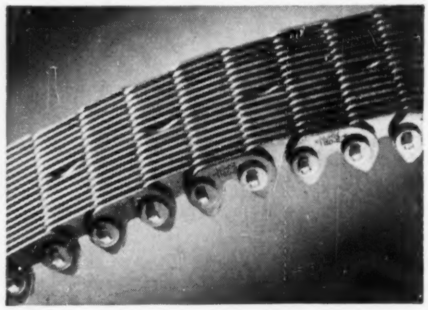
IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

MORSE MORSE B-W BORG-WARNER *

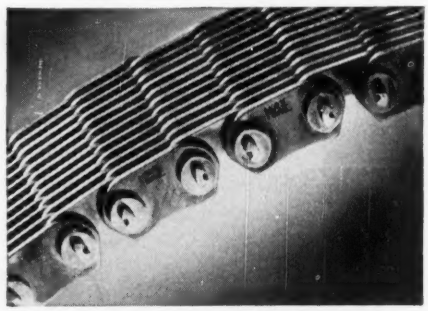
*Trademark



1. Roller Chain . . . for low- and medium-speed applications. Precision-finished—specially treated to withstand shock and fatigue. Patented Spirol Pin Fasteners.



2. Silent Chain . . . for smoother, quieter operation at higher speeds. Patented rocker joint operates with less friction and wear; runs cooler, with higher efficiency and longer life.



3. Hy-Vo Drive . . . a Morse exclusive for extremely high speeds and horsepower. Mile-a-minute speeds, up to 5,000 horsepower loads. Minimum shaft space; usually eliminates outboard bearings.

4. "Timing" Belt . . . for light weight and lubrication-free operation. Positive, efficient from 0 to 16,000 FPM, 1/1000 HP to 1,000 HP; slip- and stretch-proof for life of drive.

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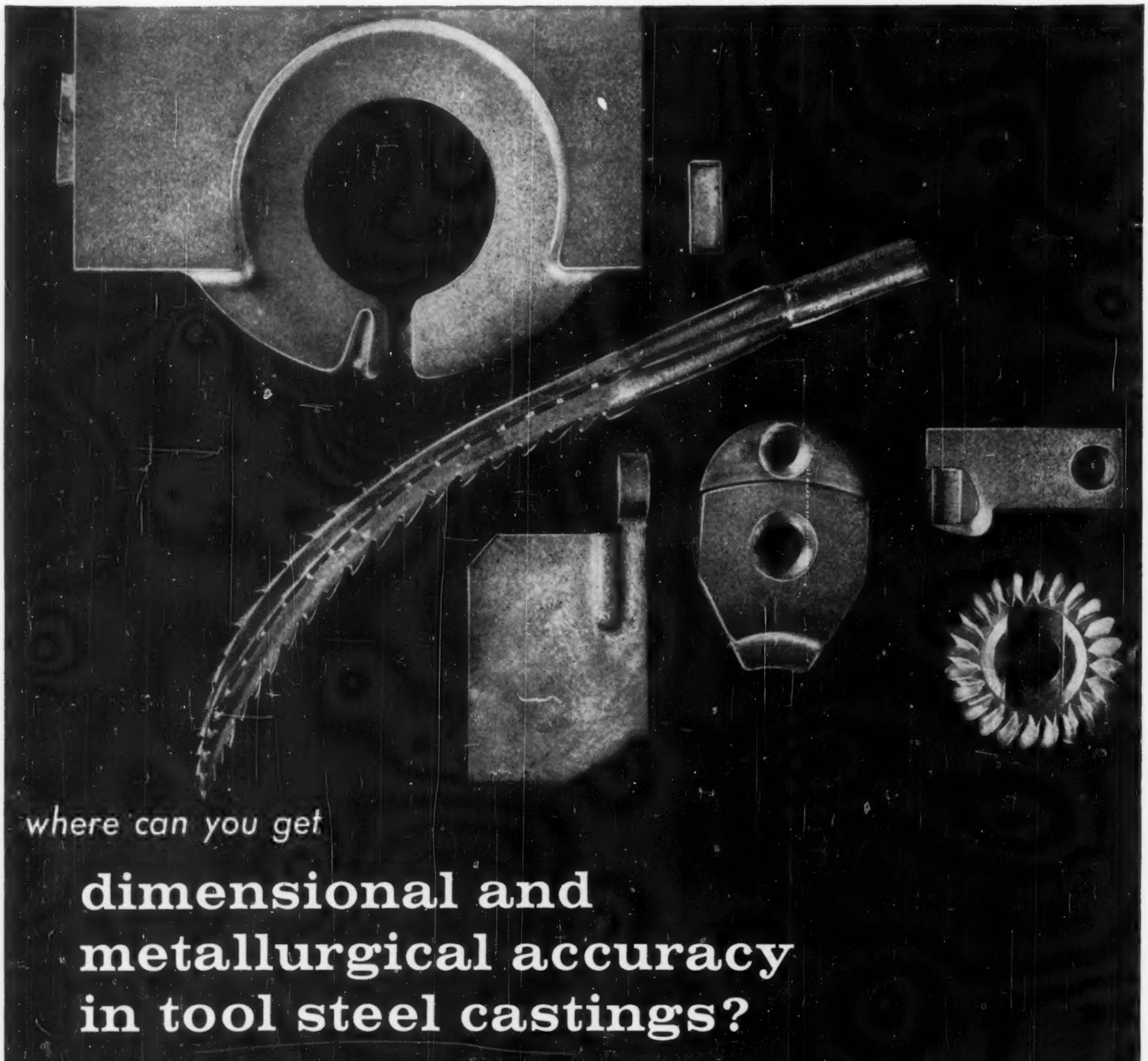
Circle 443 on Page 19



The quality of tool steel castings depends heavily on metallurgical control and foundry techniques which can be acquired only through long experience in handling tool steels. That's why it will pay you to get your castings directly from Crucible, largest and leading producer of tool steels.

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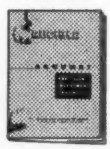

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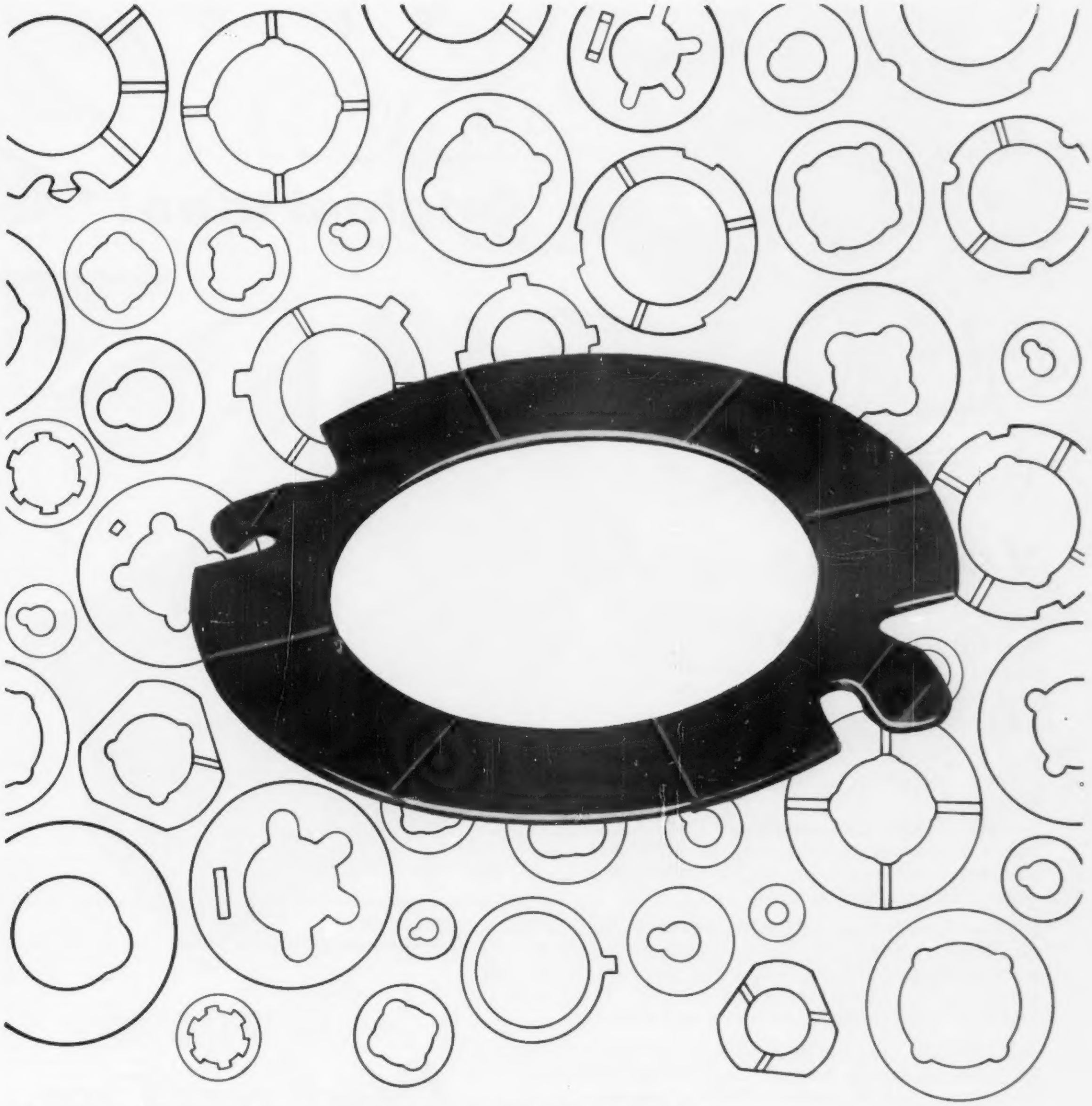

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Circle 445 on Page 19

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You Can Count On... to Pay Off!

It's the **Original Equipment* idea . . . which simply means that, when you're figuring on electrical or mechanical counters in any new product, it pays to *design them in, when you begin.*

For then Veeder-Root quite likely can save you time and money by adapting or modifying a *standard* counter to your needs, instead of a special which you might specify on your own. This solves the counter problem . . . and saves you time in engineering, purchasing and assembly.

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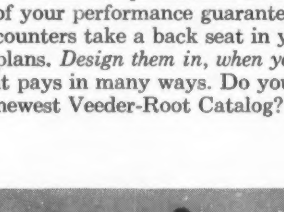

Series 1380
Box-Type Counter (Ratchet, Revolution, or Geared)

4-bank Counter for Radio Transmission Equipment

360-degree Bearing Counter

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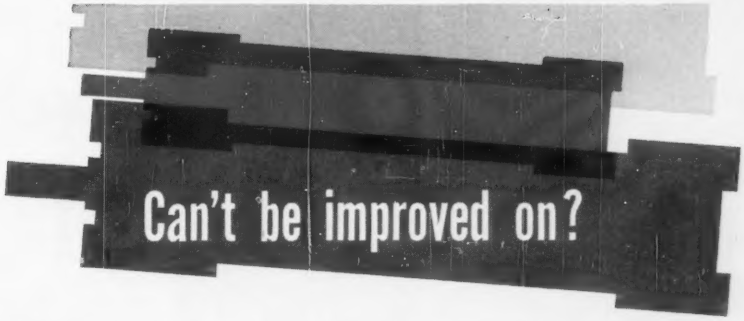
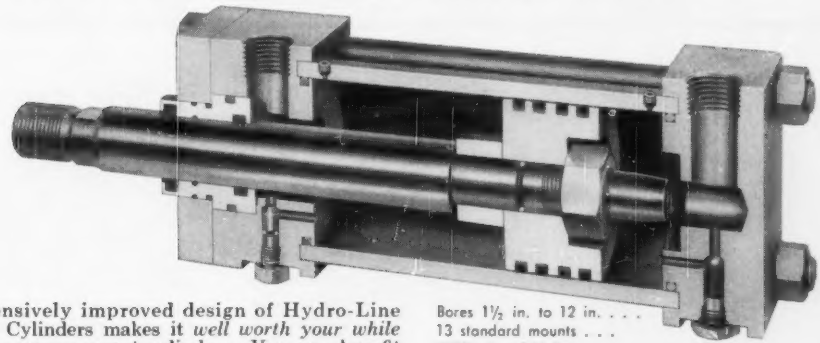


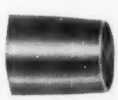
NEW POWER-PROTECTION DESIGN OF SERIES "N" CYLINDERS CUTS "UNAVOIDABLE" PROFIT LEAKS



Comprehensively improved design of Hydro-Line Series "N" Cylinders makes it *well worth your while* to reappraise your present cylinders. You can benefit from improved design in one or more of these areas.

Bores 1½ in. to 12 in. . . .
13 standard mounts . . .
2000-psi and higher operation

Hydro-Line's tapered plunger, for faster strokes, tighter cushioning without shock.



Longer bearing consolidates parts for easy maintenance, gives extra support to rod, accurate seat for wiper and seal.

Conventional bearing "A" | Power-Protection bearing | Conventional bearing "B"

Synthetic rubber wiper — machined edge wipes off dirt, prevents suction of air on instroke; wipes rod dry on outstroke.

EFFICIENCY — Are you accepting any of the following causes of power loss or imperfect performance: Imperfect oil bypass control for specific operating conditions? Poor cushioning at end of stroke or reduced speed at start? Oil leakage? Unnecessary bearing or piston friction? . . . *Every* Series "N" Cylinder offers improved protection against *all 5 of these factors* and can increase profits by increasing the amount and the dependability of power delivered!

MAINTENANCE — Downtime is dead loss. How much of it must you write off each month because of slow or complicated cylinder servicing? Lack of flexibility and interchangeability of cylinder parts? Air or dirt entering cylinders on the instroke? Imperfect bearing lubrication? Scoring or corroding of rod? . . . Series "N" Cylinders offer *11 improved features* to help keep your machines producing longer between maintenance periods . . . speed and simplify parts replacements when needed!

SERVICE LIFE — Do you receive the maximum available number of *efficient* cycles from your present cylinders in return for the initial price you pay and the time it takes to install them? Series "N" Cylinders are unsurpassed for quality of materials and construction — and a combination of *4 distinct life-extending design improvements* place them definitely ahead of conventional cylinders for length of service at *full* efficiency.

Call your nearby Hydro-Line representative today — ask for a demonstration of the *Power-Protection* features of Series "N" High-Pressure Cylinders.

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5600 PIKE ROAD — ROCKFORD, ILLINOIS

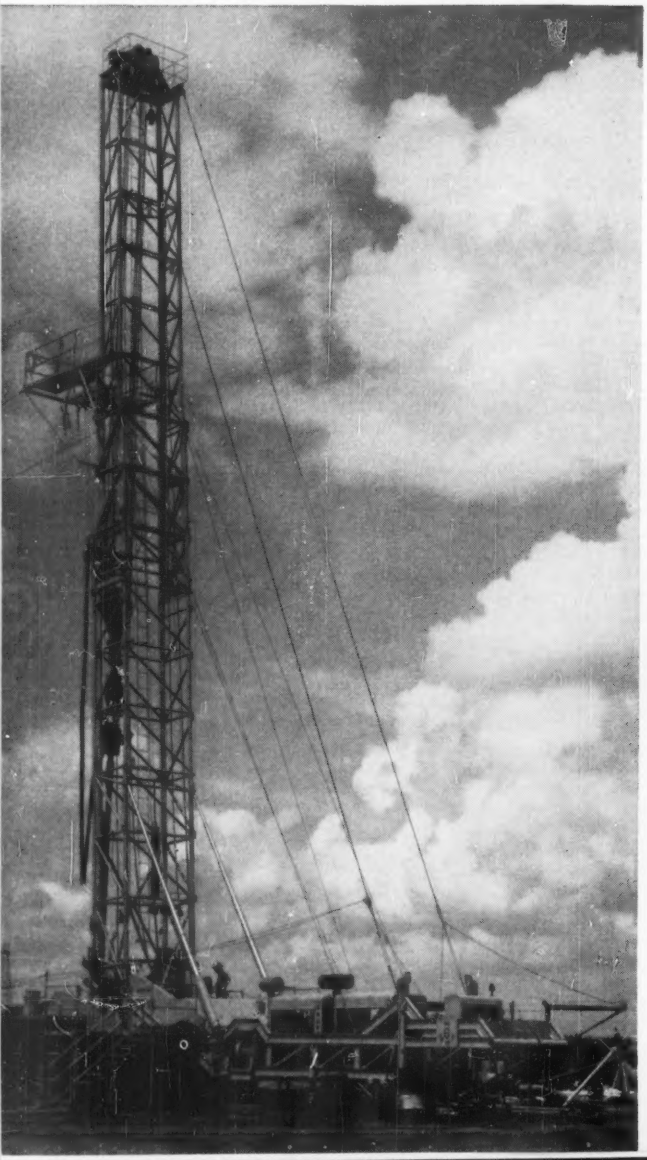
manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

 Circle 447 on Page 19

Meets high formability requirements —saves 24% weight

Here's a job that may surprise quite a few steel users accustomed to thinking of high strength steel as being "stiff" and therefore not readily formable. For in making these LP-gas containers, USS MAN-TEN Steel blanks ¼" thick are press-formed *cold* into seamless shells, 29" in diameter and 24" deep. Such an operation calls for a degree of formability that would be considered high even for carbon steel.

By taking advantage of this property, Pressed Steel Tank Co., Milwaukee, Wisc., was able to reduce the shell thickness of this Hackney container 24%, and at no increase in cost, produce a stronger, tougher and more durable container that is 102 lbs. lighter than when made of carbon steel. This saving in weight means easier handling in the shop and during installation, plus substantial savings in freight costs—both on the steel used and when finished containers are shipped.



Assures greater portability, prolongs life

In portable oil drilling rigs like this, every pound of weight saved is of vital importance. To keep weight as low as possible without sacrificing ruggedness, the Cardwell Mfg. Co., of Wichita, Kansas, has built the trailer frame and working platform of USS MAN-TEN Steel and reduced weight 6,000 lbs. as compared to structural carbon steel construction. In the 96-foot mast, which can be telescoped and folded down when the rig is moved, MAN-TEN Steel used in all the structural members reduces weight about 25%, and helps to keep moving costs down to a minimum. MAN-TEN Steel's superior strength and abrasion resistance, plus its high fatigue strength, also pay off by keeping the rig steadily on the job.

UNITED STATES STEEL
USS
HIGH STRENGTH STEELS
1933 1957
24 YEARS OF PERFORMANCE

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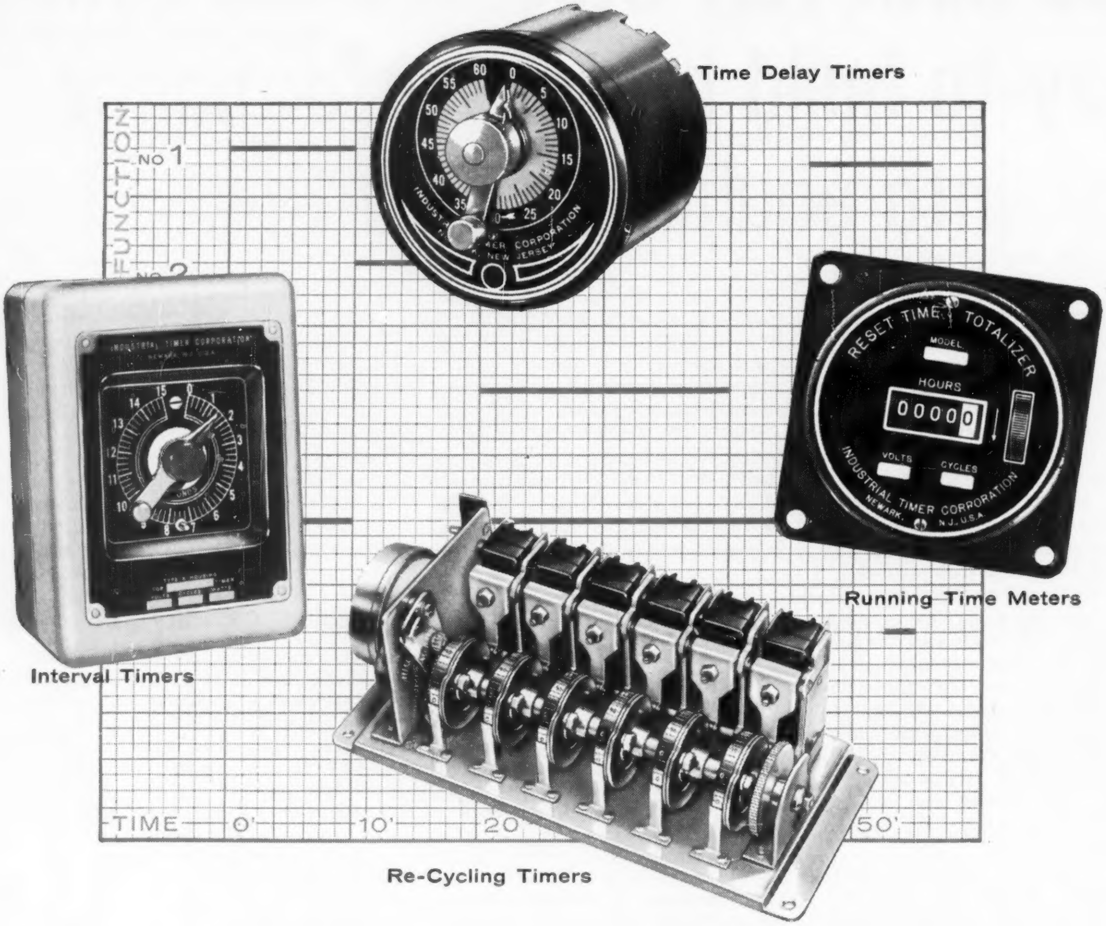

Time Delay Timers
Running Time Meters
Interval Timers
Re-Cycling Timers
FUNCTION
NO 1
TIME
0'
10'
20
50'
RESET TIME TOTALIZER
HOURS
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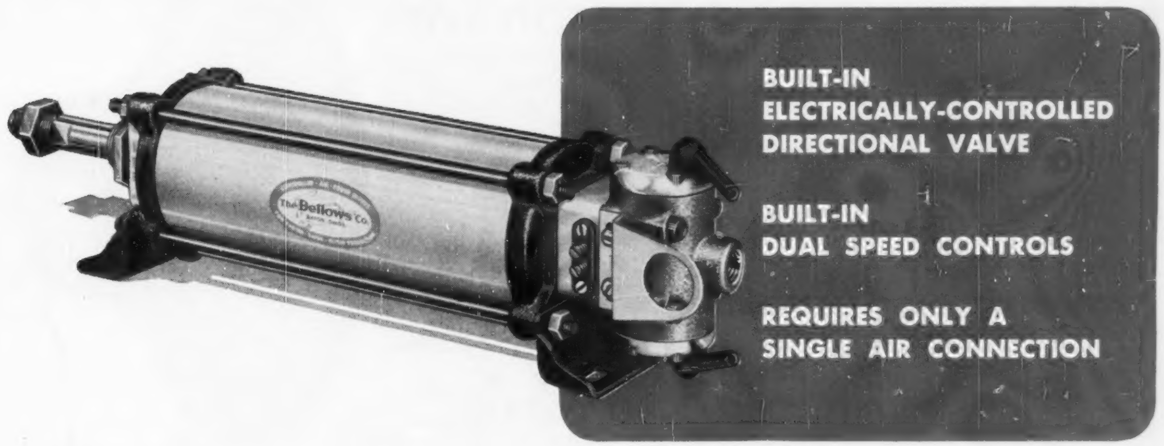
INDUSTRIAL TIMER CORPORATION

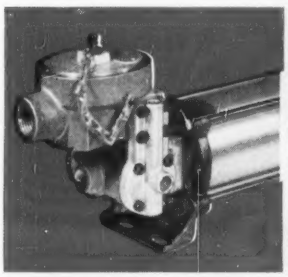
the ultimate in air cylinder power-



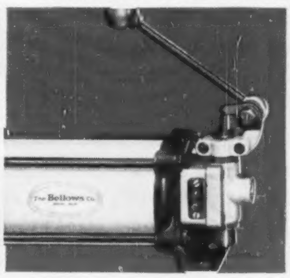
THE BELLOWS AIR MOTOR

The Bellows Air Motor is a complete air cylinder power unit, with directional valve and speed controls built-in. Takes less than half the space and costs less installed than a conventional air cylinder set-up of equal power with its separate valving and piping. The single air connection, which can be made with flexible hose, makes it ideal for use on moving machine elements. It is a sturdy unit with forged steel heads, heavy brass cylinder, stainless steel piston rod. The piston rod is threaded, equipped with a wrench flat and nut. Many Bellows Air Motors have been operating day in and day out for fifteen years with negligible maintenance. And if service needs do arise, there is a Bellows Field engineer as near as your phone. The Bellows Air Motor shown above is a 2½″ bore unit equipped with the Bellows Low-Voltage (8-12V) Electroaire Valve. Other bores available are 1¼″, 1¾″, 3⅝″ and 4½″. Any stroke length. Optional choice of built-in valves as shown below.

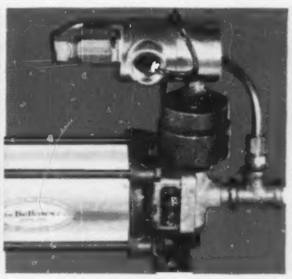
CHOICE OF BUILT-IN VALVES



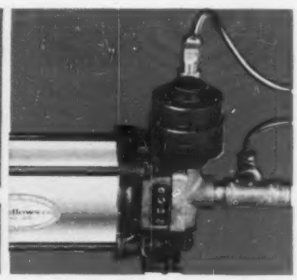
115 V. ELECTROAIRE VALVE
For J.I.C. applications where a 115 v. momentary contact is desirable.



MECHANICAL VALVE
For manual operation or for use with cams or direct linkage.



115 V. MAINTAINED CONTACT
Valve remains in shifted position during period current is applied.



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For use in applications calling for full pneumatic control.

Write for these two booklets

Fifty pages of data to help you select the right Air Motor-Valve combination for your job. Address Dept. MD 1257, The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto 18. Ask for Bulletins BM-25 and SP-55.

The Bellows Co.
DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION
AKRON 9, OHIO

983-B

Circle 451 on Page 19

MACHINE DESIGN

December 26, 1957

The Freedom to Discuss

ACCORDING to Section 1 of the *Canons of Ethics for Engineers*, "The engineer will co-operate in extending the effectiveness of the engineering profession by interchanging information and experience with other engineers and students and by contributing to the work of engineering societies, schools and the scientific and engineering press."

But engineers' efforts to interchange information and experience are being seriously hampered. Manufacturers are afraid to permit disclosure of information they have acquired through research, development, and design for fear of losing a competitive advantage. On a national level the same fears with respect to military security have led to an extreme policy of secrecy which probably has retarded our own efforts more than it has held back our potential enemies.

In urging new legislation governing exchange of nuclear information with friendly countries, Thomas E. Murray points out that ". . . the Soviet establishment is now so far advanced in all the basic scientific disciplines (mathematics, physics, chemistry) and is likewise so far advanced in all their applications to engineering research and development that the Soviet government has within its reach all the achievements that it may require for the furtherance of its military and political intentions. . . . Secrecy cannot halt Soviet progress."

Competitive and military advantages of secrecy are at best short-lived. Secrecy may even create a false sense of security. Yet we are still closely guarding information that is known to our enemies and competitors and is secret only to our own people. Now it seems that if we hadn't been so preoccupied with preserving our own secrets, and had bothered to study the Russians' own publications, we might have been tipped off to some of their recent "surprising" accomplishments.

The freedom to discuss is the lifeblood of a profession, as the Canons of Ethics —and the Russians—recognize. Those whose job it is to classify or restrict information have a grave responsibility. Leaning too heavily in the direction of supposed safety, they may so retard our own developments and those of our friends that they thereby give a competitor or enemy a clear advantage.

Engineers, being often involved in secret work, are in excellent position to judge whether disclosure would benefit the other side or whether classification would hinder ours. They should lend their knowledge and influence toward a more intelligent use of the power to withhold or to disclose.

Colin Carmichael

EDITOR

How to Organize

Engineering for Product Development

By PHILIP R. MARVIN
Manager, Research and Development Div.,
American Management Association
New York, N. Y.

EFFECTIVENESS of product-development activities can be multiplied if management's first concern is focused on being certain that basic organizational functions are both present and operating. Burden of workload in developing new products centers in the areas of research, engineering, and commercial development.

Ideas for new products are initially developed in many ways and through the efforts of many individuals, within and outside the corporation. Once ideas have been established, the research, engineering, and commercial-development departments digest these new ideas and, working with management, turn them into designs and specifications for profitable products.

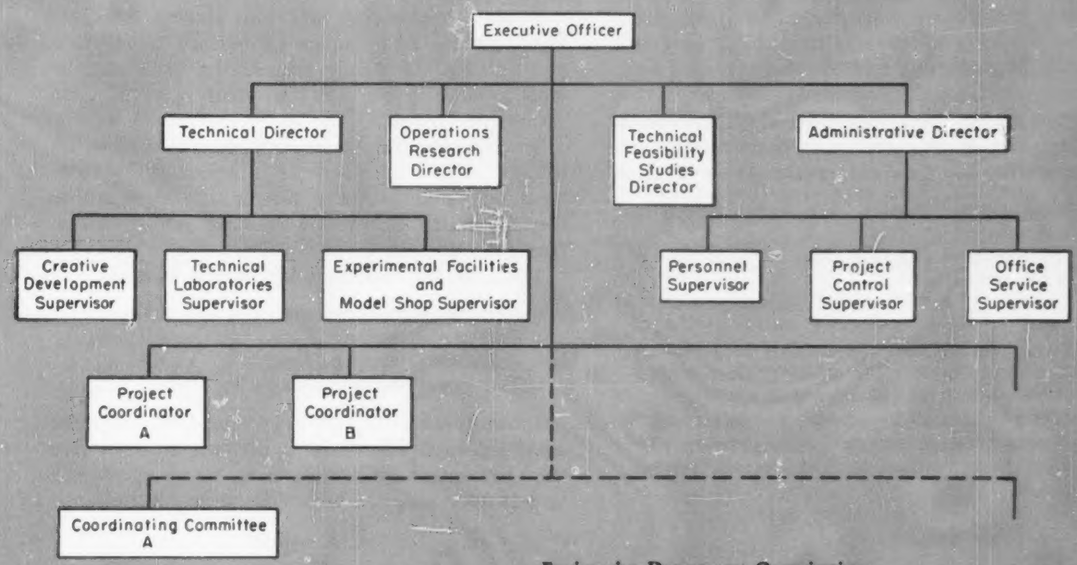
These products must be more than just pieces of hardware. They must represent items carefully selected with a view to yielding a profitable return on the investment involved and so related to the over-all activities of the corporation that the position of the corporation will be enhanced. While activities of research, engineering and commercial-development departments are closely interrelated, the respective functions involved are so distinct and different that each must be given separate attention.

Semantics introduce problems. Terminology for technical functions varies from corporation to corporation. This does not alter nature of work performed but does confuse discussions of product-development activities.

In the smaller company one man may be responsible for all product-development activities, engineering, exploration of commercial potentials of new products, and any necessary research for product development. Larger corporations can assign one or more men to each of these activities.

Every corporation carries on some product development work of a formal or informal nature. The problem confronting most companies is how to multiply effectiveness of these activities. To accomplish this result, both the staff and the organization must yield where necessary.

An attempt to increase output by effecting changes within the limits of existing organization patterns represents a halfway measure. The effective way is to establish requirements, determine organization fitted to the requirements, and then select from the present organization the personnel and facilities that fit the new patterns. This article tells how.



Engineering-Department Organization

Regardless of staff size involved, the important point is that each of these functions plays an important part in development of a successful product.

Engineering Objectives

Engineering is responsible for creating and designing a product which can be produced economically and which will perform satisfactorily in the hands of the customer. For a product to do the job expected by the customer, it must incorporate design features that fill requirements of distribution, installation, and adequate service maintenance throughout the product life. The engineer assumes broad responsibilities. He must not only be creative but he must have the capacity to turn his ideas into commercially feasible products. The engineer's job is to utilize existing knowledge in creating and designing products that can be produced and sold at a profit, concerning himself with costs as well as technology.

Strength and Weaknesses

Contrasted with the relatively limited number of really oustanding engineering organizations, most engineering groups fail to meet demands imposed by competitive industry conditions. Executives who are aware of this condition frequently experience difficulty in affecting remedial measures. While recognizing lack of satisfaction with engineering efforts, there is no certainty about how to correct existing conditions.

In many companies, engineering management might be accused of being too busy to take time to adapt its operations to new conditions. Increasing importance of technology in modern industry calls for aggressive engineering leadership. In many cases, engineering management has not recognized this need.

The engineer's own outlook has, more often than not, limited full realization of his potential to the corporation. Initially the engineer's job was to solve problems presented by management. The technical group functioned to tell management what could not be done. Many of today's engineering organizations still limit their activities to this role.

To meet today's business needs, engineering must assume a more dynamic role. First requirement is objective, long-range planning of engineering programs. Second is aggressiveness combined with leadership and initiative. Engineering counsel must be injected into corporate affairs in broad areas encompassing research, production, marketing, sales and finance if these functions are to operate at levels of effectiveness essential in a technological age. In older, established engineering organizations, bold and drastic management action will be necessary to develop streamlined, objective philosophies and a vigorous new outlook.

Objective planning for engineering organization

calls for an analysis of corporate needs, combined with knowledge of engineering functions.

Basic Engineering Functions

Twelve major categories cover the functions of the engineering organization. Their relative importance will vary from corporation to corporation.

1. Management counsel on newly developing technology.
2. Leadership in selecting areas for expansion of corporate activity.
3. Creation of new products for management review.
4. Design of commercially feasible products.
5. Technical development of all product lines.
6. Evaluation of proposed programs and projection of potential investment and expenses.
7. Development of technical data covering physical plant equipment and process requirements.
8. Maintenance of continuing quality control of operations and products.
9. Acquisition of technical skills.
10. Integration of technical information sources.
11. Development of managerial talent for technical operations.
12. Short and long-range program planning in accordance with corporate objectives.

Engineers who assume full professional responsibilities in this technological age are men who have the physical vigor and intellectual capacity to advance beyond the barriers that limit the man who must have a rule-of-thumb to guide every step he takes.

Fulfillment of responsibilities imposed by basic engineering functions calls for a combination of qualifications that encompass administrative ability, technical knowledge and skills, creative capacity, and a sense of perspective that provides a feel for the future.

Engineers meeting these qualifications do exist. Some have risen to become corporation presidents. Others are on their way up. But even more important, such talent is available in the lower echelons of engineering.

Some men are born good leaders, but in most instances leadership is developed. The costly way to acquire engineering talent is to bid in the open market. The farsighted approach is through creation of engineering organizations that develop engineering talent.

Dynamic or Static

No single organization structure is universally applicable. However, certain fundamental considerations can be established as guides. These considerations suggest action that can be taken to inject vitality into engineering organizations. In the final analysis, however, the proper course must be selected from existing alternatives. The final plan must apply these fundamentals to optimize available skills, knowledge, experience, and innate capacity at both administrative and operating levels.

Today's engineering role has become complex; rapid growth and change complicate the picture still further. Dynamic engineering organizations must replace static ones; patterns must be fluid rather than frozen.

To achieve this, four key functions are essential. These four call for a separation of technical and administrative functions, and provision for continuing operations research and technical feasibility studies.

The four key functions are represented by:

1. Administrative Director
2. Technical Director
3. Operations-Research Director
4. Technical-Feasibility Studies Director

Interpretation of the key functions depends upon ability to discriminate between local (within the corporation or trade group) usage of specific terminology and the broader underlying concepts.

The Administrative Function

Engineers often voice the complaint that too much of their time is taken up with administrative work. In many cases the complaint is justified. Not only is this a source of annoyance to the engineers, but corporations cannot afford to divert valuable engineering talent in this manner. From a management position, it is wasteful of time and money. Separation of administrative and technical assignments is essential if engineering organizations are geared for efficiency and effectiveness.

The Administrative Director is responsible for business relationships in the engineering organization. His area of activity can be further divided into three general supervisory categories under his direction. In the overall, he is responsible for planning, organizing and controlling engineering-department work.

The Project-Control Supervisor is responsible for schedules. New programs to be undertaken must be broken down into manpower and facilities requirements and then compared with available supplies of each resource. Based on this analysis, time schedules are established compatible with the men, money and physical tools available for the project.

Advice of those who will actually execute programs must be relied upon for information that goes into making up schedules. The supervisor should make no attempt to act as an expert in any area of technical specialization. Rather, it is his duty to search out counsel to establish reliable estimates.

Once programs are initiated, the project-control supervisor measures progress, with the assistance of the technical staff, against the original estimates. Deviations from schedules indicate need for revised schedules. Original and revised sched-

ules reveal the degree to which objectives are being achieved in accordance with expectations.

The Personnel Supervisor is responsible for recruitment and placement of all personnel in the engineering organization and for professional-development programs. Final selection of candidates for positions is made by individual supervisors and those designated by them to make this selection. Complete indoctrination of new members of the staff, and all other personnel relationships in the engineering organization, are the responsibility of the personnel supervisor.

The Office-Service Supervisor is responsible for providing secretarial staff, report-preparations facilities, library services and related functions essential to smooth working of the engineering organization.

The Technical Function

The Technical Director is responsible for quality and quantity of the engineering-department output. Engineering output is informational in nature and takes the form of designs, detailed drawings, data, instructions, and reports relating to products, processes, applications, and facilities of many types. The technical director is responsible for acquiring or developing the latest knowledge and skills and applying these to achieve optimum results at the earliest time commensurate with low costs.

The technical function can be subdivided into creative development, technical laboratories, experimental facilities, and model development.

The Creative-Development Supervisor is responsible for all design and engineering development programs. Here, products, processes, and facilities take shape. Problems may arise that call for investigational and analytical work in the technical laboratories or the model shop by the experimental group. Results of such programs feed back to the creative development group for reference and incorporation in new designs and developments.

The Technical-Laboratories Supervisor is responsible for developments of skills and facilities essential to engineering analysis. Continuing effort should be expended in a regular program with the objective of developing new and better technical tools. These skills and facilities enable engineering to achieve new horizons as basic engineering data are developed.

The Experimental-Facilities and Model-Shop Supervisor is responsible for construction and operation of models to learn performance characteristics. Such information is an essential part of engineering design and development activities.

Operations Research and Technical Feasibility

Short-range programs of the engineering department would not be noticeably impaired if these two functions were omitted—but long range internal development, operationally and technically, would suffer greatly. These functions serve to prod internal development. They are antidotes to stagnation.

Operations Research is concerned with analysis of performance, not only in products of the engineering organization, but the organization itself. Alternate courses of action are compared, analyzed and new procedures are established to optimize total effectiveness.

Technical-Feasibility Studies provide parallel knowledge of new skills and potentially useful techniques and materials. This study is purely an exploratory function and is only indirectly related to scheduled programs. Technical-feasibility studies start with the premise that current programs are relatively obsolete. Based on this assumption, new approaches to technical problems are needed, new products and processes should be explored, new techniques created, and new skills developed.

The technical-feasibility studies group has the assignment of recommending specific courses of action to continually revitalize the technical phase of engineering operations. At the same time, the operations-research group has responsibility for making specific recommendations growing out of analyses of procedural and functional relationships.

Both operations research and technical-feasibility studies provide recommendations for future planning. Both serve to combat organizational and operational stagnation. Established as formal activities, these two functions have a better opportunity of surviving the insidious inroads of immediate problems—daily demands usually of the first order of inconsequence. Daily demands, if allowed to get out of control, can result in ultimate deterioration of engineering effectiveness.

Project Administration

The engineering project itself forms the necessity for an engineering organization. Dominant role of the engineering project must never be overshadowed by prima donnas in supporting roles. Engineering effectiveness is measured in terms of successfully completed projects. The critical phase of sound project administration is establishing adequate liaison and providing management guidance.

The Project Co-ordinator is responsible for managing the project and, with co-operation of a co-ordinating committee, for establishing liaison essential to successful execution of the project. Number of projects assigned to an individual project co-ordinator is determined by magnitude of programs involved. In addition to project responsibilities, project co-ordinators may

have other assignments. For example, they may have engineering assignments as technical specialists on projects other than those directly under their administration. Technical manpower is a scarce resource. Its application must be sufficiently flexible to permit optimum utilization.

At initiation of a project, the engineering executive assigns it to the co-ordinator best qualified to manage that particular type project. Administrative capacity is the primary qualification essential in selecting project co-ordinators. A secondary qualification is broad knowledge of the technical area of the project. A broad background is more important than a high degree of specialization.

The project co-ordinator first studies the problem area and background of events leading up to initiation of the project, with a view to establishing a co-ordinating committee. This committee includes individuals who have a direct interest in the project. The committee charts the course the project will follow and the project co-ordinator is responsible for keeping on this course.

Engineering analysis and design are responsibilities of the technical director. Staff members are assigned to the project by the technical director and his supervisors. Management control data are developed by the administrative director. The project co-ordinator is responsible for the overall program.

The Engineering Executive is responsible for creation and design of products that will prove profitable to the corporation in both short and long-run periods. Product of the engineering group is the information that enables manufacturing to produce a product, and distribution to sell a product, that will provide the ultimate customer with the performance he seeks.

The role of the engineering executive is an exacting one. Technical proficiency, breadth of thinking, and perspective in outlook must be combined in both today's product and products comtemplated for the days ahead.

This role is not for the mechanic, the recluse, or the timid man. The engineering executive must be an aggressive leader of management thinking. His leadership must reflect competence, courage, and co-operativeness if he is to command respect of his management associates.

Looking Ahead

An expanding economy in a technological age places exacting demands on engineering organizations. Not all engineering groups have adequate strength to meet these demands. Dynamic engineering organizations that have the capacity to grow are expanding rapidly. Stagnant engineering groups are spending their time explaining why advanced programs cannot be carried out. Top management should not be saddled with such resistance. Combatting negative attitudes is a serious drain on management energy.

Remedial action can be taken, but bold and drastic action will be required in many corporations. Successful remedial action is dependent upon executive ability to tailor individual organizational patterns to corporate objectives established for the days that lie ahead.

BIBLIOGRAPHY

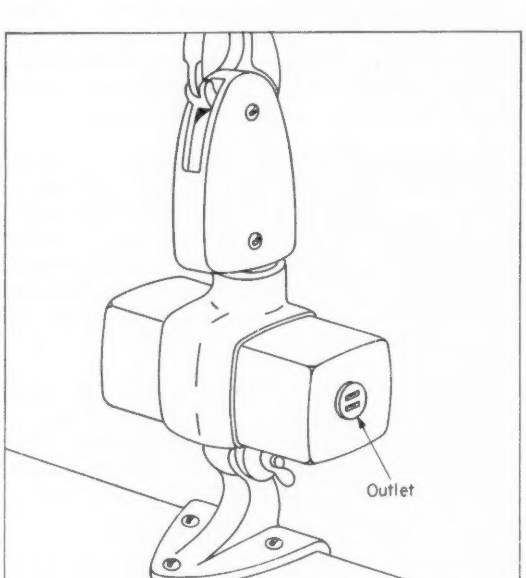
This article, and its companion, "Research for Results," MACHINE DESIGN, October 17, 1957, cover the interrelationship between research and engineering. They are the fifth and sixth in a co-ordinated group by Dr. Marvin on development of new products. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

"Planning Product Strategy" .... June 13, 1957
"Developing Ideas for New-Product Programs" .... July 11, 1957
"Profitable Fields for New-Product Development" .. August 8, 1957
"Screening and Appraising New-Product Ideas" September 5, 1957

Tips and Techniques

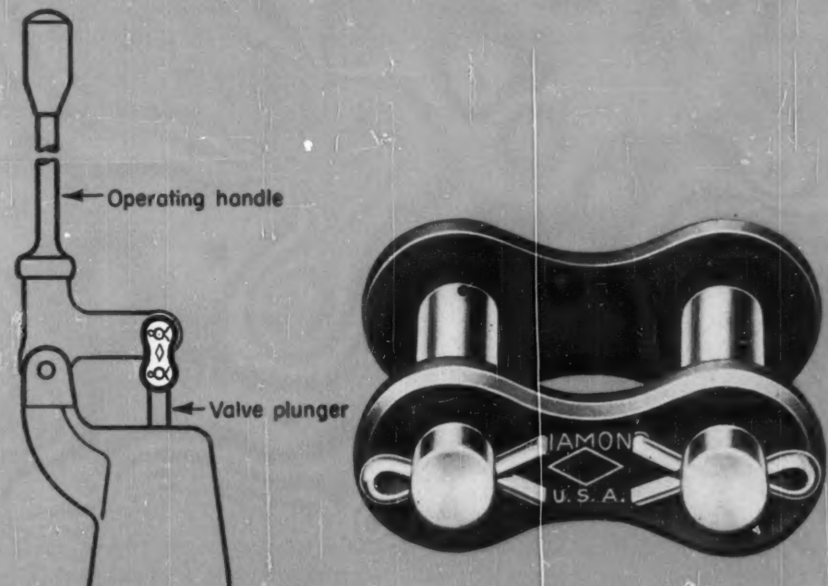
Eraser Outlet

A plastic or porcelain socket, fastened to the surface of the transformer cover of a floating-arm, drawing-table lamp, provides a convenient outlet for an electric erasing machine. A minimum of wire is needed for hook-up since connection may be made inside cover. This arrangement eliminates dangling wires and drop cords.—ROBERT LAVENDER, *engineer, Ordnance Devices Test Section, Lockheed Aircraft Corp., Missiles Systems Div., Van Nuys, Calif.*



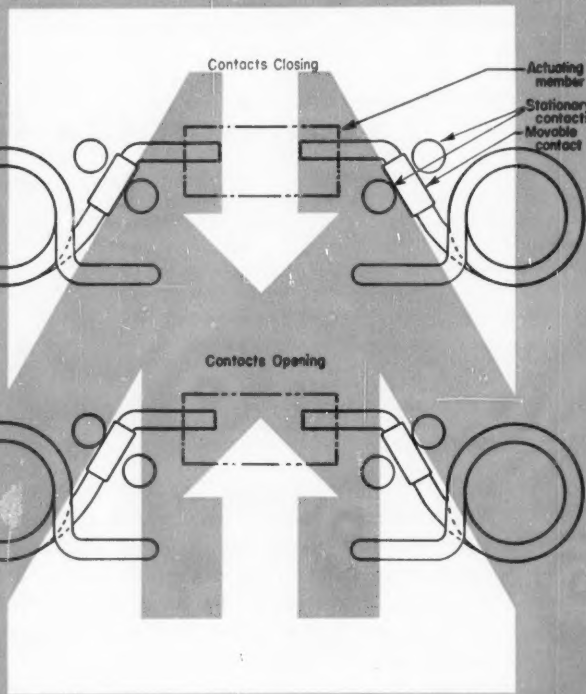
scanning the field for *ideas*

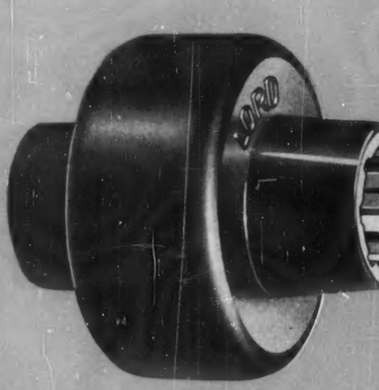
Roller-chain joint is employed in a linkage construction that makes use of standard commercial parts to reduce costs and simplify design. In an assembly designed by Galion Iron Works & Mfg. Co., a standard roller-chain, cotter-pin connecting link is used to connect an operating handle with the plunger of a hydraulic valve. Use of the purchased component eliminates need for engineering and manufacturing a special part.

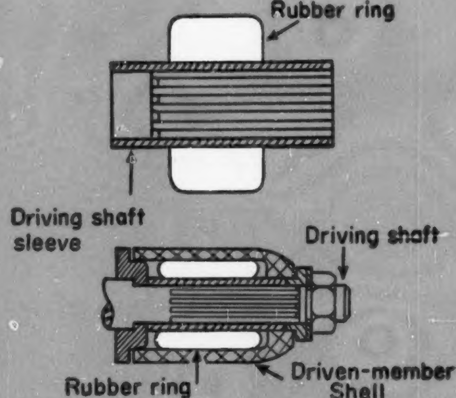


Photo, courtesy Diamond Chain Co. Inc.

Wedge-action electrical contacts provide self cleaning and achieve positive contact under extremes of environment and operating conditions. The movable contact is a torsion-spring member, rigidly anchored at one end and restrained at the other end in a movable switch-actuating member. Movement of the actuating member causes the moving contact to touch the stationary contact, and then wipe over its surface with constantly increasing pressure. The wedging action removes contaminants from the contact surfaces, reducing electrical resistance, and maintains contact under shock and vibration. Electro Tec Corp. developed the design.

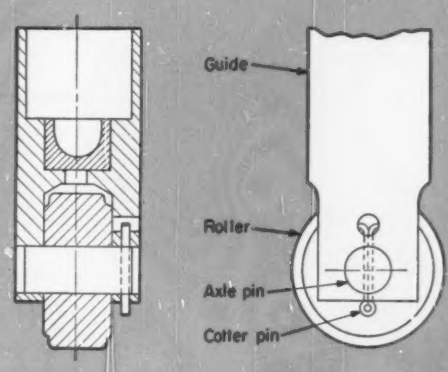






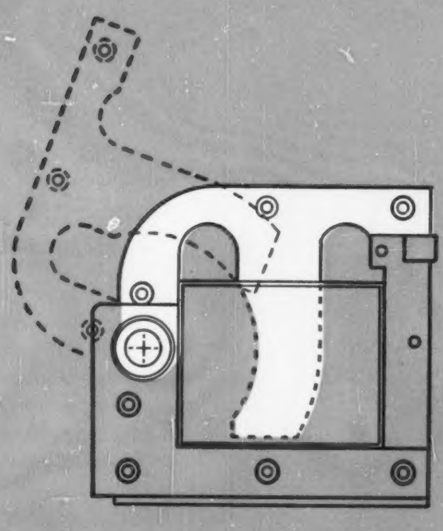
Rubber-ring slip clutch provides "cushioned" power transmission between driving and driven members, yet permits automatic disconnection under excessive load. Designed to replace a conventional shear-pin assembly, the clutch employs a rubber ring that is bonded to the driving shaft and compressed within a shell on the driven member. Moderate interference or overload of driven member is accommodated by torsional deflection of the ring; severe interference causes the clutch ring to slip. The clutch was developed by Lord Mfg. Co. for application in a marine outboard motor.

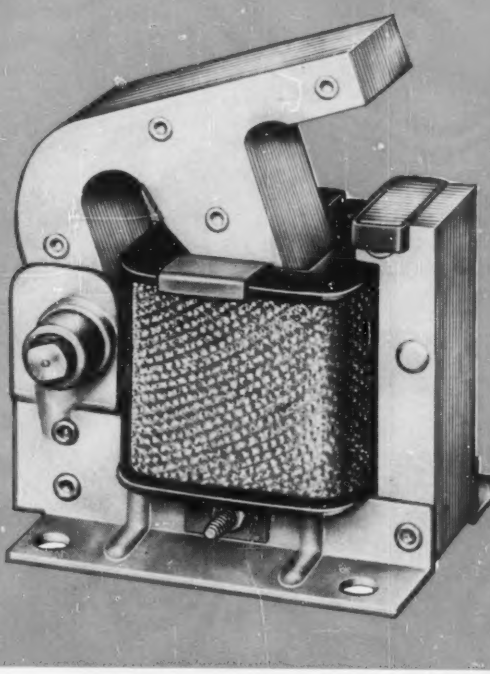
ideas



Cotter pin locking of small axle assemblies subject to shock and vibration loads simplifies design and production problems. The technique, developed by White Diesel Engine Div. of White Motor Co., provides for positioning and locking an axle pin in a cam-follower assembly. The design permits use of a straight, headless axle pin and eliminates need for undercuts or recesses for locking devices in the axle-pin hole. Easy assembly and disassembly of the cotter pin is provided by drilling only two straight holes. After the cam roller and axle pin have been assembled into the rod guide, the cotter is inserted through its hole in the guide and axle pin. The legs of the cotter pin are spread and locked against the sides of a small hole by inserting a tool in the hole after the pin is in place.

Hinged armature design in rotary solenoid permits movement along an arc with negligible torque reduction. Essentially a push-pull solenoid in operation, the design developed by Roto Mfg. Co. employs an F-shaped plunger. The plunger rotates about an axis perpendicular to the coil centerline, rather than parallel as in most rotary solenoids, to develop wider arc of travel.

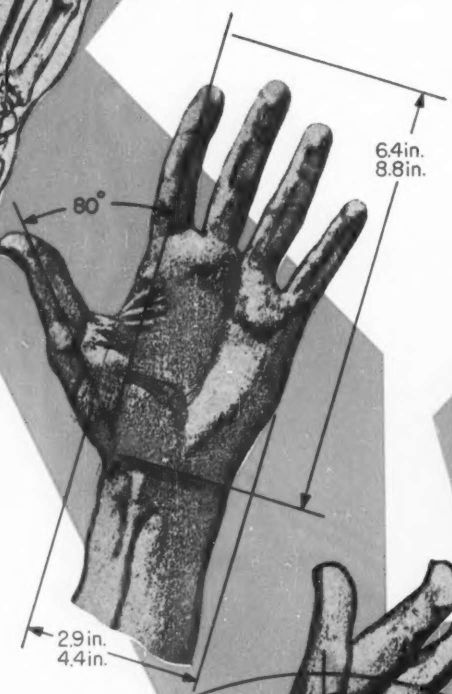




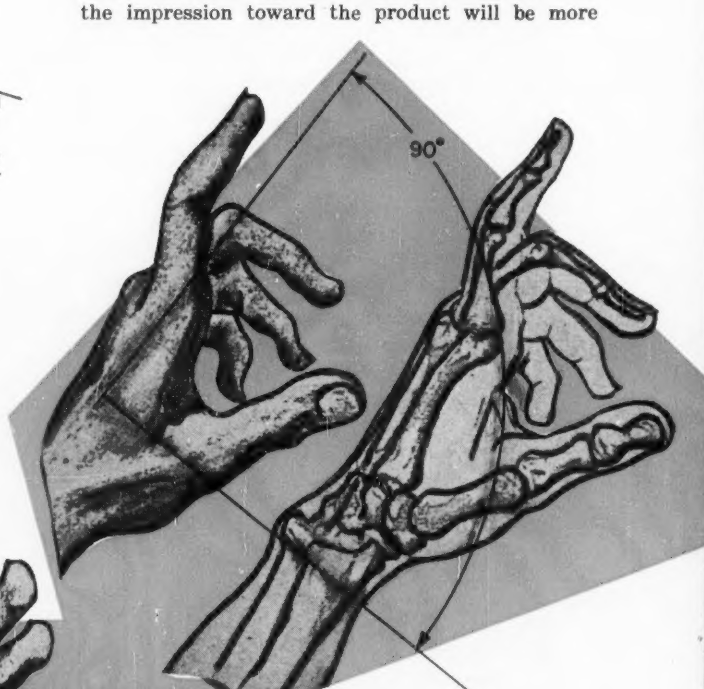
Designer's Sketchbook for

By DOUGLAS R. WITT
Director
Imagination Unlimited
St. Paul, Minn.

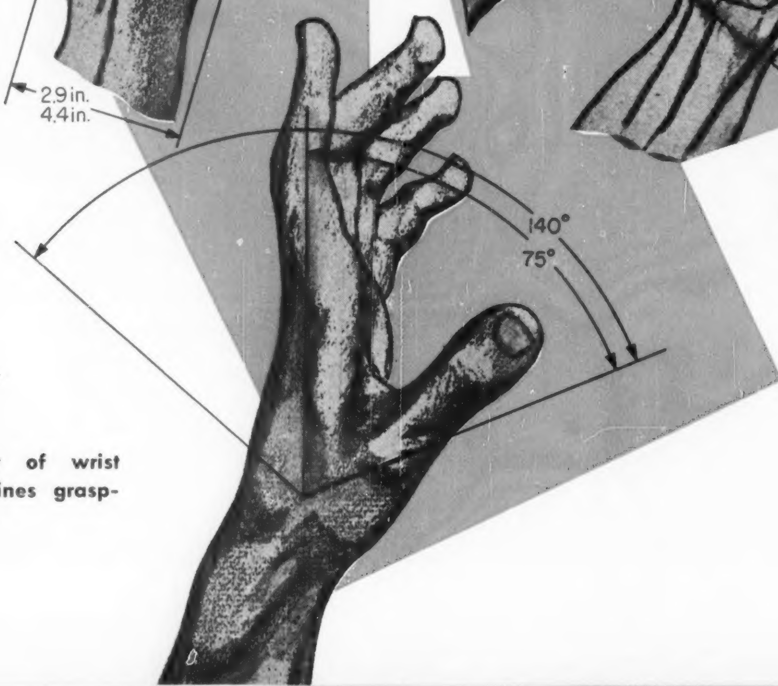
Before designing a hand control, the engineer must take two points into consideration: The human hand, and the type of control required. Whatever the hand control—knob, button, or lever—the hand must grasp it and push, pull, or twist it. If it is easy for the hand to do this, chances of operator error are reduced and the impression toward the product will be more



Average dimensions of the human hand



Maximum arc of finger flection is 90 deg



Flexibility of wrist joint defines grasping area

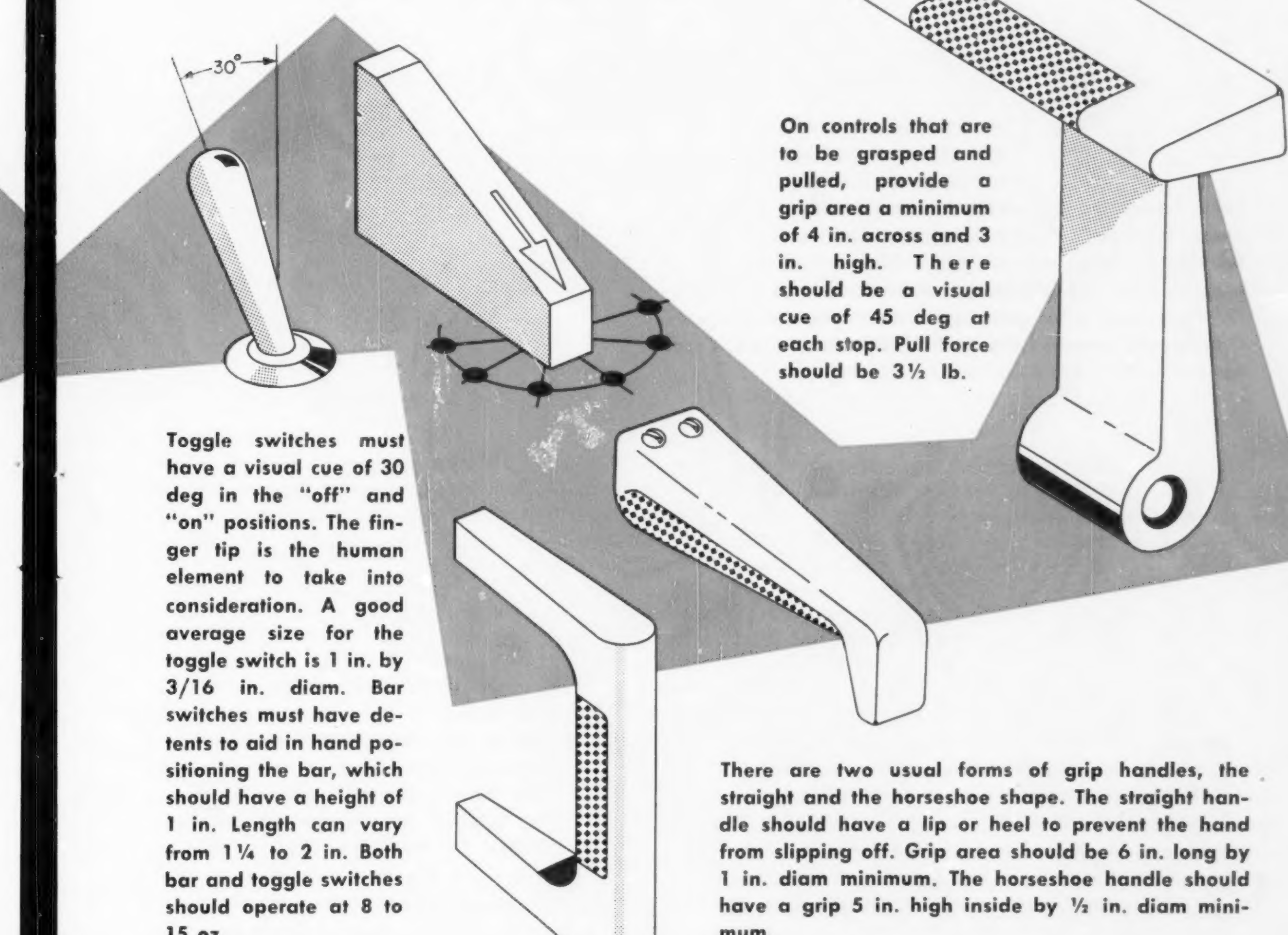
Hand-Control Design

favorable. Size and shape of a control must be determined by the hand if it is to give satisfactory service.

Four factors should be taken into consideration when designing a hand control:

1. Determine what the control must do.
2. Determine conditions where control is used.
3. Make sketches of possible control designs.
4. Refine sketch design for economical cost.

Every control should be designed for its specific use and operating conditions. For example, a radio control knob on the home set is usually operated under ideal conditions of light and heat. However, this same set operated in a dusty machine shop would require a larger knob with an indicator skirt because of poor light and temperature conditions.

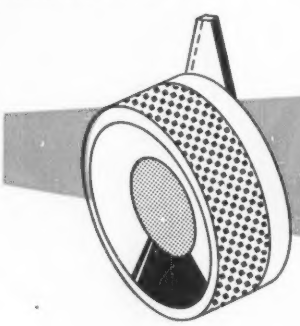


On controls that are to be grasped and pulled, provide a grip area a minimum of 4 in. across and 3 in. high. There should be a visual cue of 45 deg at each stop. Pull force should be 3½ lb.

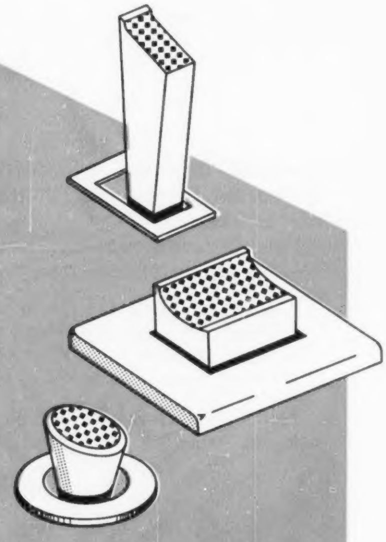
Toggle switches must have a visual cue of 30 deg in the "off" and "on" positions. The finger tip is the human element to take into consideration. A good average size for the toggle switch is 1 in. by 3/16 in. diam. Bar switches must have detents to aid in hand positioning the bar, which should have a height of 1 in. Length can vary from 1¼ to 2 in. Both bar and toggle switches should operate at 8 to 15 oz.

There are two usual forms of grip handles, the straight and the horseshoe shape. The straight handle should have a lip or heel to prevent the hand from slipping off. Grip area should be 6 in. long by 1 in. diam minimum. The horseshoe handle should have a grip 5 in. high inside by ½ in. diam minimum.

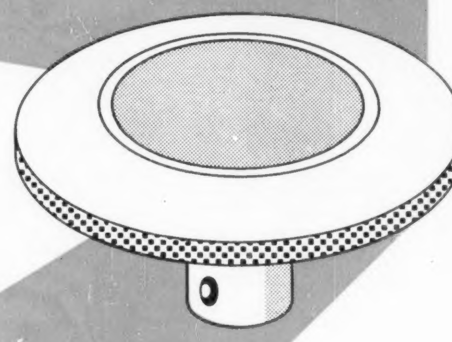
Three popular styles of knob controls are with skirt, pointer, or both. A knob skirt should be ¾ in. wide for easy reading with knobs of ¼ in. diam and up. For tight space, increase knob length to 2 in. and add a pointer to the skirt; knob diameter should be ½ in. and up. A popular knob design is ¾ in. by 2 in. diam with a pointer for critical adjusting. Small knobs are good for noncritical adjustments. Use detents if space requirements are small or if vibration may affect the setting. Large knobs are best if adjustments are critical.

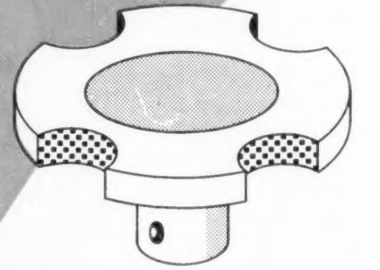


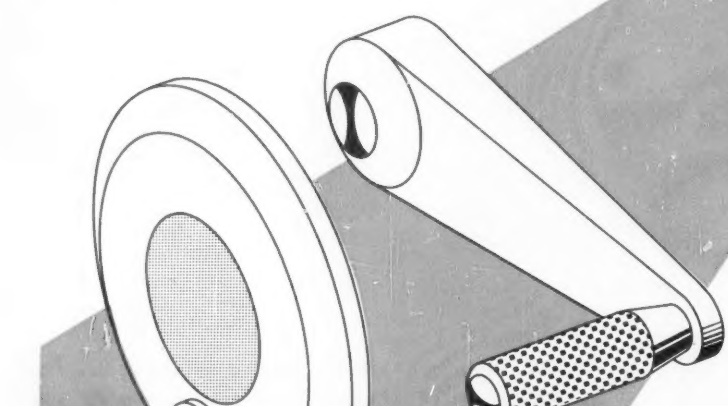
Push surface on button controls should be large enough for the finger tip to fit comfortably. A square area of ¼ to ½ in. is best. There should be a click when the button is depressed. For ease of use, button height should be a maximum of 1 in.



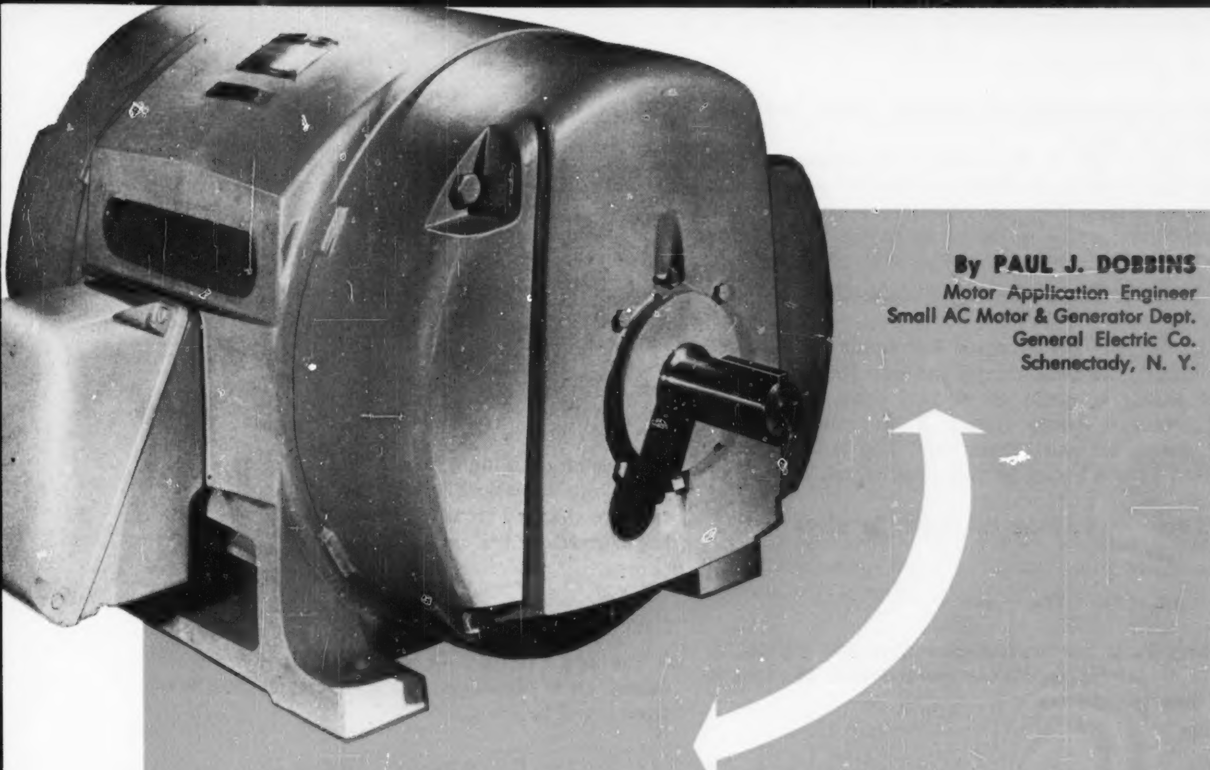
Slow, heavy crank controls are best handled by an arm crank. If properly designed, loads of 6 lb and up are easily handled. Recommended dimensions of grip are 1¼ in. diam by 6 in. long. High-speed cranking is best done by flywheel cranks for easy wrist and finger movements; Grip handle should be 5 in. long by ¾ in. diam. Crank force should be 2 to 4 lb.







Periphery of handwheels may be left smooth. This design is satisfactory for firm-holding. If positive-holding is needed, the wheel should be fluted for the fingers. Usual diameters are 5½ to 7 in. Allow ¾ in. between product surface and underside of handwheel for finger space.



By PAUL J. DOBBINS
Motor Application Engineer
Small AC Motor & Generator Dept.
General Electric Co.
Schenectady, N. Y.

Formulas for **Applying Induction Motors** *on rapid-reversing duty cycles*

IN AN application where the electric motor is started and plug-reversed quite frequently, the selection of the motor depends primarily upon temperature rise, not torque requirements. The temperature rise must be kept within the limits of the class of insulation used. From kinematics, formulas can be developed which give both stator and rotor motor losses during acceleration and plugging.

The design of a rapid-reversing motor is different from that of a so-called "standard" motor, and it follows that the procedure used to select a rapid-reversing motor for a particular reversing cycle is different from that used to select a standard motor. In applying a standard motor it is necessary only to know the load that the motor must carry and the torque necessary to start the load along with the maximum torque requirements. To apply a rapid-reversing motor it is necessary to know the following: 1. Number of times per minute motor will be called upon to plug reverse. 2. External intertia referred to the motor shaft. 3. Power output between reversals, if any. It is assumed the number of poles, voltage, phases, enclosure, ambient temperature and atmospheric conditions are known.

The class of insulation is often dictated by ambient temperature, type of enclosure, or space requirements. The temperature rise of a motor is a function of the losses in the motor during the plugging and load-carrying period, if any, along with the ability of the particular mechanical construction of the motor to dissipate the losses. The latter is determined by the motor manufacturer from tests on motors of the same mechanical construction.

It is quite common to rate rapid-reversing motors by the number of free reversals they can perform. This figure indicates that there are three sources of heat or losses. These include no-load

losses, acceleration and plugging losses, and load losses, if any.

First of all, it is necessary to determine the relation between the rotor and stator losses during a start, a plug stop, and a plug reversal.

▶ Rotor Power During Acceleration

During the period when the motor rotor is accelerated, the total energy put into the rotor from the stator is made up of two equal parts. One part is the energy stored in the rotating parts of the motor and driven load. The other is composed of the losses in the rotor which appear as heat.

Power input from the stator is given by the formula

$$P = T\omega_s = T\omega + T(\omega_s - \omega) \qquad (1)$$

where $T\omega$ is the mechanical output and expression $T(\omega_s - \omega)$ represents the power losses. The torque is determined from

Nomenclature

C_1 = Motor cooling constant
g = Acceleration of gravity, ft per sec²
I_o = Moment of inertia, lb-ft-sec² $= \frac{WK^2}{g}$
K = Radius of gyration, ft
N = Number of equivalent starts per min
P = Power input from stator, ft-lb per sec
R_1 = Equivalent-circuit rotor resistance, ohms
R_2 = Equivalent-circuit stator resistance, ohms
S = Rotational speed, rpm
T = Torque, lb-ft
T_L = Load torque, lb-ft
T_M = Developed motor torque, lb-ft
t = Time, sec
t_s = Time to reach synchronous speed, sec
W = Weight, lb
w_1 = Stator loss, w
w_2 = Rotor loss, w
w_{NL} = No-load motor losses, w
w_{SL} = Stray-load loss, w
X_1 = Equivalent circuit rotor reactance, ohms
X_2 = Equivalent circuit stator reactance, ohms
α = Instantaneous acceleration, rad per sec²
ΔT = Motor temperature rise, deg C
ω = Instantaneous speed, rad per sec
ω_s = Synchronous speed, rad per sec

$$T = I_o\alpha \qquad (2)$$

or expressed in weight units with the substitution of $d\omega/dt$ for α

$$T = \frac{WK^2}{g}\,\frac{d\omega}{dt} \text{ lb-ft}$$

If Equation 1 is integrated from the limits of $t = 0$ to $t = t_s$, the following integral for the power input to the rotor results:

$$\int_{t=0}^{t=t_s} P\,dt \qquad (3)$$

If Equation 1 and then Equation 2 are substituted into Equation 3, and the limits of integration are changed from $\omega = 0$ to $\omega = \omega_s$, the following expressions are obtained:

$$\int_{\omega=0}^{\omega=\omega_s} T\omega_s\,dt = \int_{\omega=0}^{\omega=\omega_s} \frac{WK^2}{g}\,\omega_s\,d\omega = \frac{WK_2\,\omega_s^2}{g} \qquad (4)$$

The rotor output, or mechanical power, is obtained from Equation 1 and, if it is integrated from $\omega = 0$ to $\omega = \omega_s$,

$$\int_{\omega=0}^{\omega=\omega_s} T\omega\,dt = \int_{\omega=0}^{\omega=\omega_s} \frac{WK^2}{g}\,\omega\,d\omega = \frac{WK^2}{g}\,\frac{\omega_s^2}{2} \qquad (5)$$

The rotor losses are also found from Equation 1 if it is integrated from $\omega = 0$ to $\omega = \omega_s$, or

$$\int_{\omega=0}^{\omega=\omega_s} T(\omega_s - \omega)\,dt = \int_{\omega=0}^{\omega=\omega_s} \frac{WK^2}{g}(\omega_s - \omega)\,d\omega = \frac{WK^2}{g}\,\frac{\omega_s^2}{2} \qquad (6)$$

Equations 5 and 6 show that the rotor output is equal to the rotor loss.

The equation most generally used to determine the watt-seconds during acceleration is developed as follows: From Equation 6

$$\frac{WK^2}{g}\,\frac{\omega_s^2}{2} = \frac{WK^2}{32.2}\,\frac{(2\pi S/60)^2}{2} = (1.7 \times 10^{-4})\,WK^2 S^2 \text{ lb-ft}$$

To change the units from lb-ft units to w-sec, multiply by 1.356 since 1 lb-ft = 1.356 joule or w-sec. Thus,

$$w_s = (2.3 \times 10^{-4})\,WK^2 S^2 \qquad (7)$$

where w_s is expressed in w-sec units.

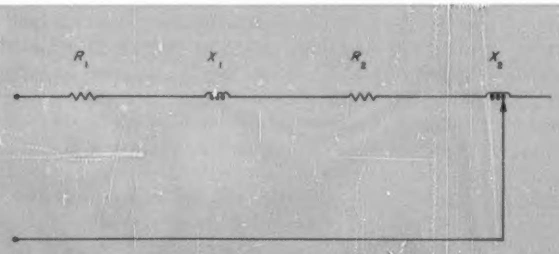


Fig. 1—Equivalent circuit for an induction motor. Terms R_1 and R_2 represent the resistance in the rotor and stator, respectively, whereas X_1 and X_2 represent the reactance in the rotor and stator, respectively.

▶ Stator Loss During Acceleration

To find the total loss during acceleration, the stator loss must also be determined. The stator loss is equal to the rotor loss multiplied by R_1/R_2. This can be derived from the use of an approximate equivalent circuit of an induction motor, Fig. 1.

The expression for w_1, the stator loss, is

$$w_1 = I_1^2 R_1 \tag{8}$$

or

$$I_1^2 = \frac{w_1}{R_1}$$

The formula for w_2, the rotor loss, is

$$w_2 = I_1^2 R_2 \tag{9}$$

or

$$I_1^2 = \frac{w_2}{R_2}$$

Therefore, since

$$\frac{w_1}{R_1} = \frac{w_2}{R_2}$$

or

$$w_1 = \frac{w_2 R_1}{R_2} \tag{10}$$

▶ Plugging

When a motor is plugged from full speed to standstill, the losses in the motor are three times those which develop during one acceleration. Since the rotation of the flux field is changed from one direction to the opposite direction while the rotor is still rotating in the first described direction, the limits for integration are now from $\omega = -\omega_s$ to $\omega = 0$. From Equation 1 and the above limits for integration,

$$\int_{\omega=-\omega_s}^{\omega=0} T\omega_s\, dt = \int_{-\omega_s}^{0} \frac{WK^2}{g}\,\omega_s\, d\omega = \frac{WK^2}{g}\,\omega_s^2 \tag{11}$$

This is the power put into the rotor from the stator.

The rotor output is found by using Equation 1 and the limits of integration, $\omega = -\omega_s$ to $\omega = 0$, or

$$\int_{\omega=-\omega_s}^{\omega=0} T\omega\, dt = \int_{-\omega_s}^{0} \frac{WK^2}{g}\,\omega\, d\omega = -\frac{WK^2}{g}\,\frac{\omega_s^2}{2} \tag{12}$$

Since the right-hand side of this expression is negative, it indicates that either the energy is added to the rotor or mechanical energy is converted to electrical energy. The former condition is the object of plugging.

The losses in the rotor during plugging are obtained by using Equation 1 and integrating between $\omega = -\omega_s$ and $\omega = 0$, or

$$\int_{\omega=-\omega_s}^{\omega=0} T(\omega_s - \omega)\, dt = \int_{-\omega}^{0} \frac{WK^2}{g}\,(\omega_s - \omega)\, d\omega$$

$$= \frac{3WK^2}{g}\,\frac{\omega_s^2}{2} \tag{13}$$

This expression shows that plugging losses are three times the acceleration losses shown in Equation 6 and represents the sum of Equations 11 and 12.

▶ Power Loss During Acceleration

If there is load torque present during acceleration, its effects can be handled as follows:

$$T_M = T_M\,\alpha + T_L = T_M\,\frac{d\omega}{dt} + T_L \tag{14}$$

where T_M = developed motor torque in ft-lb and T_L = load torque in ft-lb. From Equation 14 for $dt = T_M d\omega/(T_M - T_L)$. This value of dt, substi-

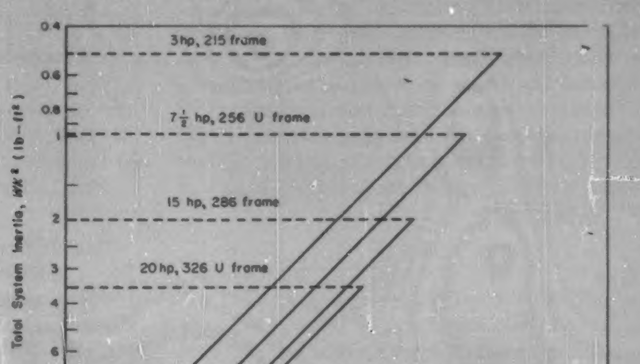


Fig. 2—Curves showing how total system inertia affects permissible number of motor reversals per minute for a 50 C temperature rise. Curves are for typical four-pole dripproof motors.

tuted in the left-hand side of Equation 6, gives

$$\int_{\omega=0}^{\omega=\omega_s} I(\omega_s - \omega) \frac{T_M}{T_M - T_L} d\omega$$

Since T_M and T_L are considered constant quantities for the particular interval used, even though they vary during the cycle, these terms can be brought outside the integral sign giving

$$w_2 = \frac{T_M}{T_M - T_L} I \int_{\omega=0}^{\omega=\omega_s} (\omega_s - \omega) d\omega$$

or from Equation 7

$$w_2 = (2.3 \times 10^{-4}) WK^2 S^2 \frac{T_M}{T_M - T_L} \text{ w-sec} \qquad (15)$$

▶ Motor Temperature Rise

The following equation can be used to determine the temperature rise of a motor operating on a rapid-reversing cycle, or it can be employed to solve for the number of reversals required to hold a given temperature rise:

$$\Delta T = \frac{\frac{NWK^2}{60}(2.3 \times 10^{-4})(S^2)\left(\frac{2R_1 + R_2}{R_2}\right)}{C_1} + \frac{w_{NL} + w_{SL}}{C_1} \qquad (16)$$

where ΔT = temperature rise in deg F, w_{NL} = no-load losses in w, N = number of equivalent starts per min, C_1 = cooling constant which the motor manufacturer determines from test on motors of the same construction, and w_{SL} = stray load loss.

Note that the stator losses are weighted twice since experience has shown that this loss has a greater effect upon the temperature rise measured by resistance and on windings by thermocouple.

From Equations 5, 6, 11, 12, and 13, it can be seen that the losses from one plug stop are equal to the losses from three accelerations and for one plug reversal the losses are equal to four accelerations. Expressed another way, one acceleration = $1N$, one plug stop = $3N$, one plug reversal = $4N$.

For any given motor design the number of free reversals can be calculated by use of Equation 16 rearranged as

$$N = \frac{\Delta T\, C_1 - w_{NL}}{\frac{WK^2}{60}(2.3 \times 10^{-4})(S^2)\left(\frac{2R_1 + R_2}{R_2}\right)} \qquad (17)$$

With the point obtained from Equation 17, a curve can be drawn to give the number of reversals for any given external WK^2. See the graph in Fig. 2 which is a typical curve for a rapid-reversing motor. These curves are all drawn for a given temperature rise and have total system inertia plotted against number of reversals.

Examples

1: Assume that a typical rapid-reversing motor has the following specs: NEMA design D, four pole, 7½ hp, 1800 rpm, 220/440 v, three phase, 60 cycle, 50 deg C rise, dripproof, R_1 = 0.15 ohms, R_2 = 0.60 ohms, no-load current = 8 amp, core loss = 140 w, rotor WK^2 = 1 lb-ft^2, C_1 = 48.

From these data

$$N = \frac{50(48) - 169}{\frac{1}{60}(2.3 \times 10^{-4})1800^2 \frac{0.9}{0.6}} = \frac{2400 - 169}{187} = 119.5$$

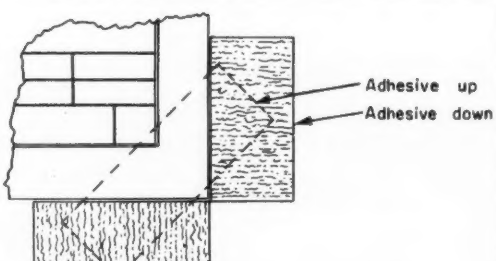
Since it has been shown that one plug reversal is the equivalent of four starts or $4N$, the number of reversals permissible is $N/4 = 119.5/4 = 29.9$.

2: Assume that the motor in Example 1 is to be used to drive a machine which has a total system inertia of 2 lb-ft^2 referred to the motor shaft. What is the number of reversals that can now be obtained from this motor keeping within the rated temperature rise of 50 deg C?

Looking at the graph in Fig. 2 with total inertia of 1 + 2 or 3 lb-ft^2, the 7½ hp motor can perform 9.7 reversals and meet the temperature rise conditions.

Tips and Techniques

Prevent Catching Tape



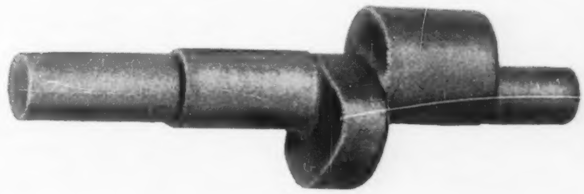
Drafting tape used to fasten paper to the board has a tendency to roll up under the T-square or straight edge. This can be prevented by using three short strips of tape, as shown. The diagonal strip is placed, adhesive side up, on the underside of the paper. The other two strips are placed outside the edges of the paper, adhesive side down.

When the same size drawing is used repeatedly, tape can be left on the board for subsequent drawings by lifting the previous drawing off.—JACOB W. E. ROTH, *Wesley, Ark.*

Impact resistance of

GRAY IRON

By **FRANZ R. BROTZEN** Rice Institute Houston, Texas and **JOHN F. WALLACE** Case Institute of Technology Cleveland, Ohio



Gray iron — although usually considered a "brittle" metal—has the ability to resist moderate shock conditions. Three factors which should be considered in selecting the most suitable type of gray iron for shock applications are:

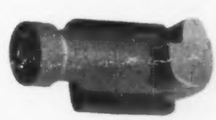
- **Significance of impact tests**
- **Relative impact resistances of grades of gray iron**
- **Effects of composition and structure on toughness**

These factors are discussed in this article —the second of a co-ordinated series on fatigue and impact properties of gray and nodular irons.

IMPACT resistance or toughness is a measure of the ability of a material to resist fracture upon sudden application of a load. This property is measured by the amount of energy required to fracture a metal specimen with a rapid load application. The standard notch Charpy and Izod impact tests frequently employed for steel and other metals do not yield a sufficient spread to differentiate between the relative toughness of various gray irons. Accordingly, these specimens are replaced by larger, unnotched test specimens of gray iron.

The concept of a transition temperature from ductile to brittle failure is not involved in the impact testing of gray iron because of camparatively low ductility. Since gray iron does have sufficient toughness for many purposes, it is necessary to differentiate between impact resistances of various types of iron to permit selection of the required grade. The large, unnotched specimens of gray iron serve the purpose of spreading the quantitative range of energies required for fracture, thereby permitting a differentiation between the toughness of various types. Significance of impact tests, test conditions, specimen dimensions and compositions will be discussed in this article.

Impact Tests: Single-blow impact tests include the Izod, Charpy, and tension impact tests. The



Izod test uses a 0.798-in. machined diameter cylinder 3 in. long clamped in a cantilever position and fractured with a pendulum-type hammer. The Charpy test for gray iron uses a $1\frac{1}{8}$-in. diam cylinder placed on two supports 6 in. apart and broken by striking with a pendulum midway between the supports. A good correlation in impact results is generally observed between Izod and Charpy type tests. The tension-impact test finds little use because of excessive scatter in the results.

Table 1—Impact Resistance for Various Classes of Gray Iron

Class	Izod Impact (ft-lb)	Class	Izod Impact (ft-lb)	Class	Izod Impact (ft-lb)
30	23	40	31	50	65
35	25	45	36	60	75
				50 Heat treated	120+

All three tests measure the amount of energy removed from the swinging pendulum by the fracture of the impact specimen.

The American repeated-blow impact test consists of dropping a hammer from increasing heights upon a cylindrical specimen until fracture. The European or Krupp-Stanton test involves dropping a standard weight hammer a set distance upon a rotating cylindrical specimen for a number of times until fracture. Repeated-blow impact tests have been utilized to develop differences in toughness not evident from single-blow tests. However, results are only comparative in nature and frequently do not correlate with other tests or different conditions. Data show that the single-blow impact test is less sensitive than a repeated-blow impact test at higher impact values. The Krupp-Stanton test often has some correlation with single-blow tests, and results indicate that gray iron can be superior in toughness to cast steel even though single-blow tests show the reverse.

Temperature has only a slight influence on toughness of gray iron because type of fracture is not affected. Temperatures over 900 F result in a slight increase in impact resistance as measured in single-blow tests. Subatmospheric temperatures usually cause a small decrease in energy absorbed during fracture.

Correlation of Impact Resistance and Other Properties: Toughness generally increases with increasing tensile strength, although under some circumstances a relatively low-strength ferritic iron may possibly exhibit higher impact resistance than a stronger but less flexible iron. A general relationship between various classes of gray iron and the energy required for fracture of a 1.2-in. diam unnotched bar in the Izod type test[1,2] is shown in Table 1. A similar comparison between impact resistance with a Charpy type bar and the tensile strength demonstrates an excellent straight-line correlation. In both cases, energy required for fracture increased with increasing tensile strength.

Since the only significant difference between the Charpy impact test of gray iron and the transverse test is one of loading velocities, a close correlation between the results of this test is anticipated and is actually demonstrated for $1\frac{1}{8}$-in. diam bars[3] in Fig. 1. Results of repeated-drop tests also exhibit some correlation with transverse rupture strength although more scatter occurs. Impact resistance correlates with hardness and this relationship has been expressed mathematically. However, many structural and composition differences in the irons can influence this relationship markedly.

Effect of Composition and Structure: Impact resistance is appreciably influenced by composition. Typical results of a comprehensive study of the effect of alloy additions on impact resistance, as

[1]References are tabulated at end of article.

Table 2—Impact Results for Various Types of Gray Iron

Sample No.	Tensile Strength (psi)	Hardness (Bhn)	AB Izod (ft-lb)	Transverse* Load (lb)	Transverse* Deflection (in.)	Composition§ (per cent) TC	Si	Mn	Ni	Cr	Mo	Cu	S	P
1	47,300	262	19	4035	0.09	2.35	2.26	0.66	...	...	...	...	0.10	(0.1)
2	67,800	255	42	6595	0.17	2.26	2.69	0.66	0.82	...	...	...	...	...
3	36,100	208	21	3800	0.10	2.76	1.99	0.61	...	...	...	...	(0.1)	(0.1)
4	53,100	212	32	4985	0.19	2.76	(2.3)	0.61	(0.7)	...	...	...	(0.1)	(0.1)
5	43,700	235	22	4210	0.13	2.93	1.92	1.0	...	...	...	...	0.1	0.04
6	50,300	228	40	5110	0.21	2.93	(2.3)	1.0	...	...	...	...	0.1	0.04
7	40,000	228	16	3690	0.10	3.01	1.66	0.75	...	...	...	...	0.10	0.10
8	45,300	215	36	4880	0.17	3.01	(1.9)	0.75	...	...	...	...	0.10	0.10
9	51,700	223	41	5160	0.18	3.01	(1.8)	0.75	...	...	...	...	0.10	0.10
10	36,100	203	30	4010	0.16	3.32	1.85	0.72	...	...	...	...	0.09	0.17
11	30,100	187	25	3630	0.17	3.40	2.54	(1.0)	...	...	...	...	(0.1)	(0.1)
12	21,600	158	21	2470	0.17	7.78	2.42	(1.0)	...	...	...	...	(0.1)	(0.1)
Effect of Phosphorus														
13	.....	228	20	3100	0.13	3.67	2.63	0.57	...	1.14	...	...	(0.08)	0.03
14	.....	244	20	3200	0.13	3.67	2.63	0.57	...	1.14	...	...	(0.08)	0.20
15	.....	255	16	3200	0.12	3.67	2.33	0.57	...	1.14	...	...	(0.08)	0.36
16	.....	268	11	2950	0.09	3.67	2.63	0.57	...	1.14	...	...	(0.08)	0.53
Nickel-Chromium Iron														
17	51,600	254	37	2790†	0.24	2.95	2.0	0.8	2.25	0.75	...	...	...	...
18	37,750	235	37	3680	0.13	3.14	1.56	0.66	2.24	0.62	...	...	...	...
19	41,000	241	37	4380	0.14	3.22	1.93	(0.6)	1.97	0.75	...	...	...	...
20	32,500	269	32	4000	0.14	3.29	1.47	0.42	1.44	0.85	...	...	...	...
21	39,300	228	30	3890	0.13	3.44	1.55	0.63	2.22	0.98	...	...	...	...
Nickel-Molybdenum Iron														
22	54,700	255	39	5900	0.16	3.04	2.07	0.45	2.03	...	0.34	...	...	...
23‡	52,600	...	78	6200	0.21	3.06	2.17	0.62	1.70	...	0.62	...	...	...
24‡	67,000	286	71	4500†	0.53	2.75	2.45	0.8	1.65	...	0.75	...	...	...
25‡	98,800	402	90	4590†	0.34	2.75	2.20	0.8	2.0	...	0.70	...	...	...

*Transverse tests made on 12-in. span except where indicated.
†18-in. span.
§Parentheses indicate estimated composition.
‡Acicular matrix.

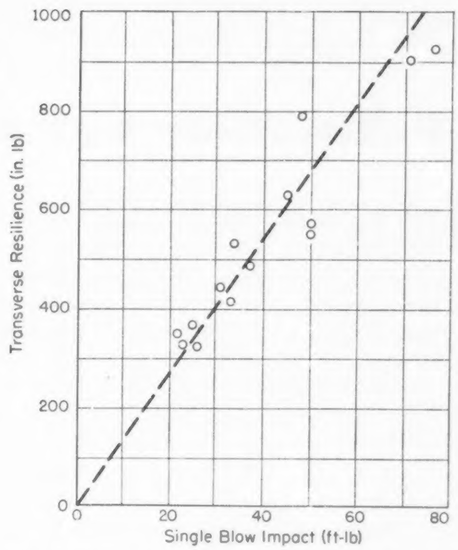


Fig. 1—Relation between transverse strength and single-blow impact resistance tests. A close correlation of results is in order since the only significant difference between tests is loading velocities.

measured by Izod tests on 1.2-in. diam unmachined bars,[4] are shown in Table 2. Influence of phosphorus, nickel-chromium, nickel-molybdenum, and high nickel-chromium austenitic irons on impact resistance is indicated. Phosphorus reduces toughness markedly—approximately 5 per cent for each

0.1 per cent increase in phosphorus. Copper as an alloy addition has little influence on impact. Molybdenum and nickel alone and in combination improve impact strength in a manner similar to improving tensile strength. While the alloy irons, particularly those with an austenitic matrix, exhibit good toughness, plain gray irons have reasonably good resistance for many uses, as shown in Table 2.

Since structure of iron is influenced by section size, impact resistance is also affected by changing casting thickness. Data from one investigation clearly indicate that for Charpy tests of several sizes and spans, toughness decreases with increasing cast diameter in a manner similar to tensile strength decreasing with increasing thickness.[5]

REFERENCES

1. F. G. Sefing—"Unappreciated Advantages of Modern Gray Iron," *Mechanical Engineering*, Vol. 70, August, 1948, pp. 667-670, 674.
2. A. Champion—"Meeting High Performance Demands in Engineering Construction with Meehanite Metal," *Iron and Steel*, Vol. 22, April, 1949, pp. 131-135; May, 1949, pp. 154-156. (*Metallurgia*, Vol. 39, March, 1949, pp. 272-276.)
3. G. P. Phillips—"Impact Resistance and Other Physical Properties of Alloy Gray Cast Irons," *Transactions*, American Foundrymen's Society, Vol. 43, 1935, pp. 125-150.
4. J. T. Eash and A. P. Gagnebin—"An Arbitration Bar Izod Impact Test for Cast Iron," *Proceedings*, American Society for Testing Materials, Vol. 51, 1951, pp. 1061-1071.
5. G. N. J. Gilbert—"The Impact Properties of Flake Graphite Cast Irons," *Journal of Research*, British Cast Iron Research Association, Vol. 5, June, 1954, pp. 298-317.

BIBLIOGRAPHY

This article is the second in a co-ordinated group of three based on "Properties of Gray Iron," from the *Gray Iron Castings Handbook* edited by Charles F. Walton, Technical Director of the Gray Iron Founders' Society Inc. The previous article and issue of MACHINE DESIGN in which it appeared are:

"Fatigue Properties of Gray Iron" .... December 12, 1957

Tips and Techniques

Stress and Weight Calculations

A great deal of calculation can be eliminated by designing according to known proportions. For example, an existing tie rod carries a known force, P_1, which creates a simple direct stress. To design a new tie rod to carry a force, P_2, under equal stresses, the cross-sectional areas should be in the ratio P_2/P_1 and linear cross-sectional dimensions should be in the ratio $\sqrt{P_2/P_1}$. Weights per longitudinal linear inch are in a ratio of P_2/P_1.

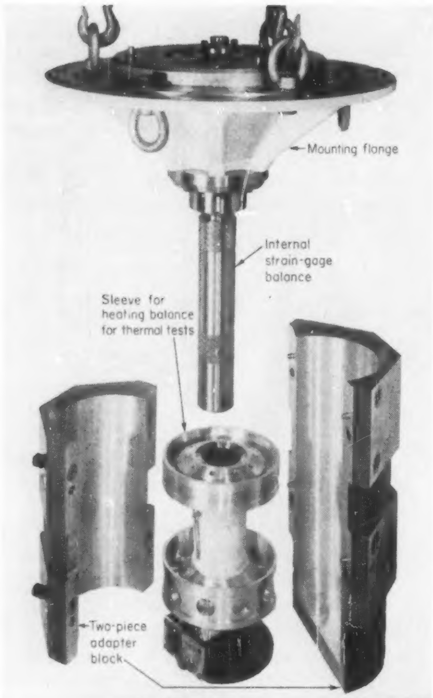
The above relationships are well known for simple, direct stresses of tension, compression or shear. For more complex stresses and loading, all linear dimensions (i.e., three dimensional) should be in the ratio $\sqrt{P_2/P_1}$ to give an exactly equal stress pattern. Therefore, total weights are in the ratio $(P_2/P_1)^{3/2}$. This applies to all the elementary formulas of stress analysis, that is, for direct shear, direct compression, direct tension, torsional shear, flexural tension, flexural compression, combined stresses, and column formulas. It also applies to radius of curvature of beams due to deflection, and unit deflections due to direct stress or flexure. The only exception is unit torsional deflection.

Cylinders of any size subject to equal working fluid pressures should have identical proportions for inner and outer diameters, wall and end thicknesses, shoulders, collars and flanges, to have equal stress conditions.

If a complete machine, or a component, is to be drawn based on a similar design of different load-carrying capacity, the new design can be proportioned from the old as outlined, if possible to do so. It is then unnecessary to calculate stresses, and weights may also be derived by a proportionate factor. In addition, the work of producing new drawings is greatly simplified, since they can be exact duplicates of the old to a new scale.—WILLIAM L. GOVAN, *Long Island, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Accurate Hydraulic Positioning System

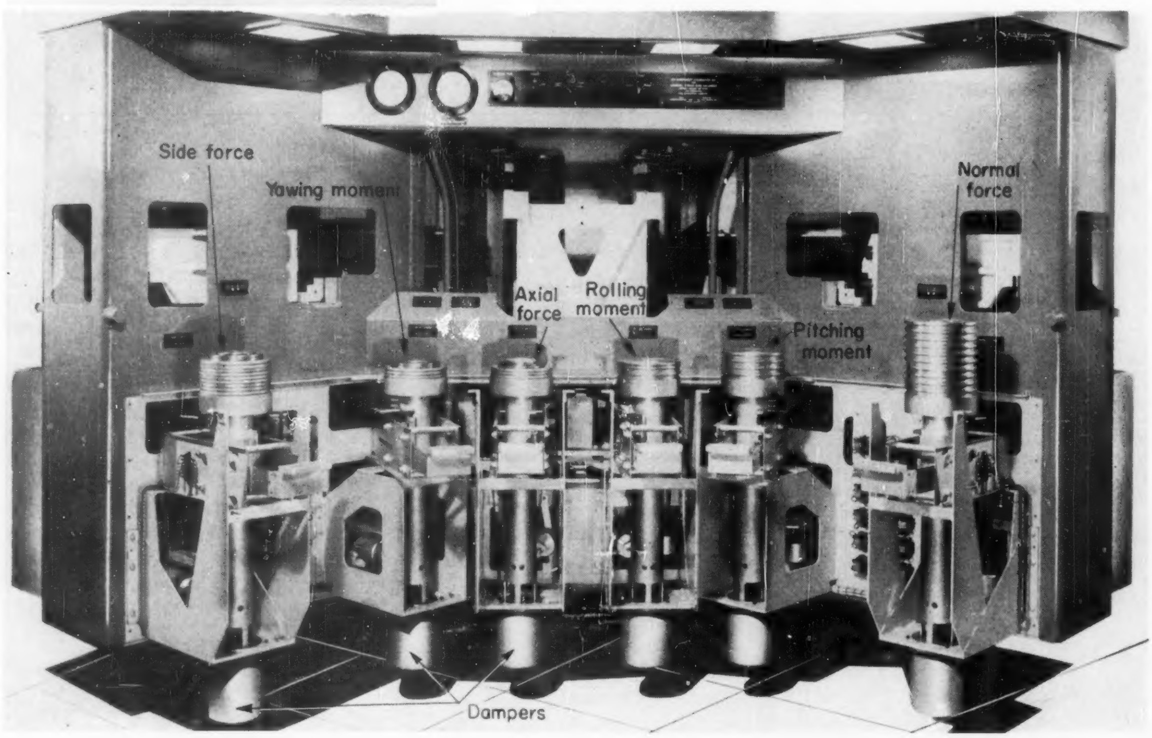


INTERNAL STRAIN-GAGE BALANCE is used to monitor the performance of model planes, missiles, and structural parts in wind-tunnel testing. Strain-gage balances of this type separate and evaluate normal, axial, and side forces plus pitching, yawing, and rolling moments of test models. The balance determines these forces simply by measuring deflection produced by the appropriate force. The balance shown is attached to a mounting flange and is about to be placed in a special sleeve used to heat the balance for thermal tests.

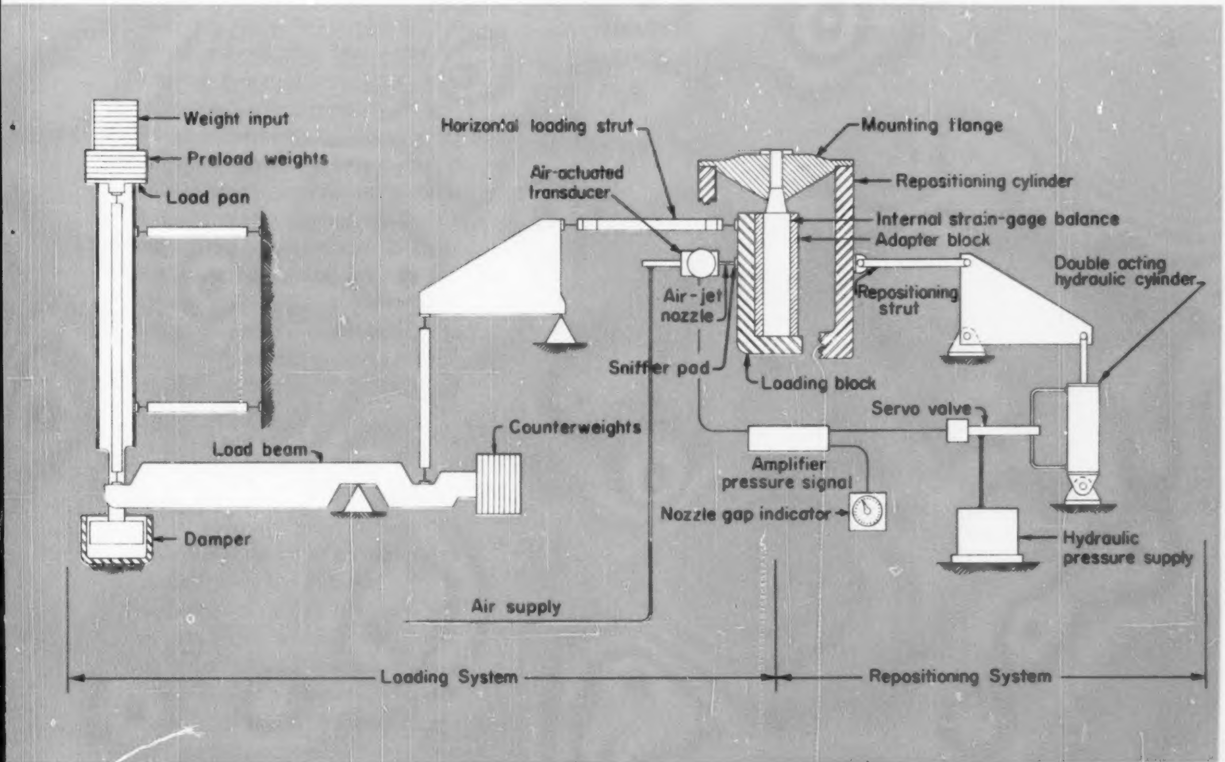
The model, under wind-tunnel study, is constructed with a cylindrical hole in it to match the outside diameter of the balance. The model is slipped over the end of the balance and pinned in place.

FAST, ACCURATE CALIBRATION of internal strain-gage balances up to 6 in. in diameter is accomplished with a new, automatic calibration apparatus designed by Sandberg-Serrell Corp., Pasadena, Calif. One such piece of calibration equipment has been installed at the NACA Ames Aeronautical Laboratory and another is on order for NACA Langley Aeronautical Laboratory.

In operation, the multiple-force calibration apparatus applies known forces to the balance being calibrated, and permits the deflections shown by the internal strain gages in the balance itself to be related directly to the appropriate load.



Uses Air-Actuated Transducers for Sensing



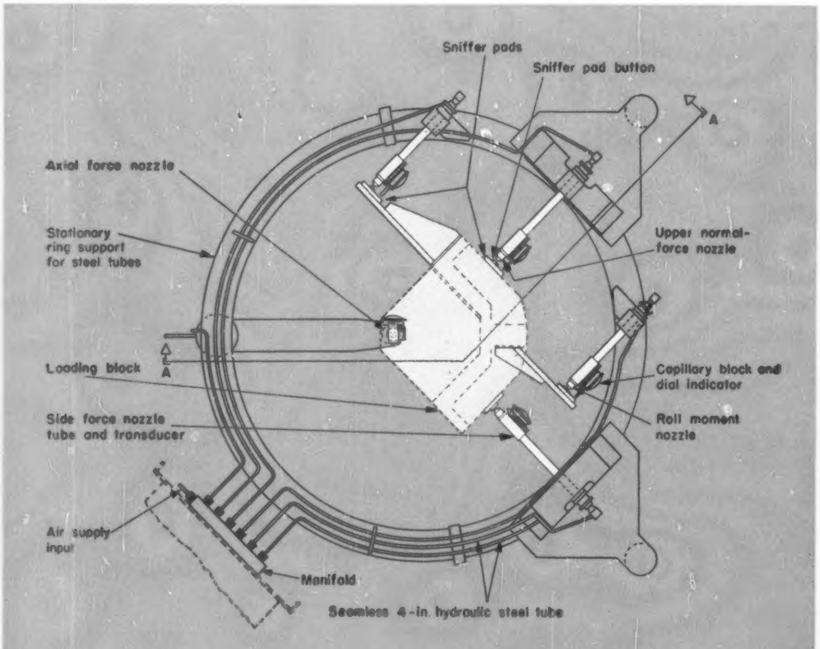
STATIC LOADING of the balance is accomplished through seven flexure-ended struts, which can introduce six force components to the balance through six lever systems. Only one such lever system is illustrated here.

Two struts are used to apply rolling moment. Six horizontal loading struts are connected by bellcranks to load beams, which in turn support the load pans. One vertical loading strut for producing axial force is connected directly to a load beam. The lever systems for the three forces operate on a 100 to 1 ratio and the three moments on a 1000 to 1 ratio.

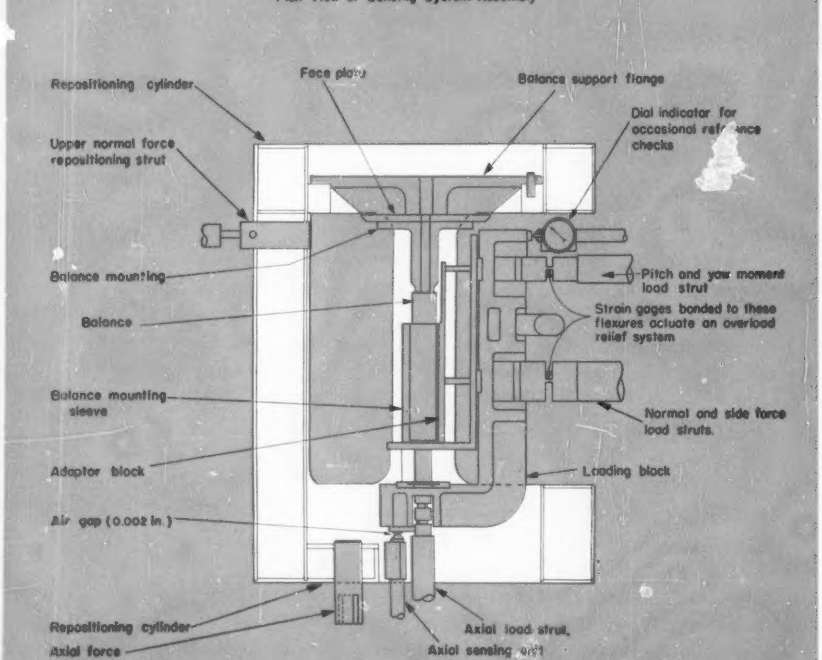
Calibration loads consist of accurate weights which are stacked on the load pans. The load beams are counterweighted so that a total weight, equal to the full-load range of the particular component, must be on the load pan when no load is applied to the balance. In this way, weights added to the balancing stack will induce a positive loading, and weights removed a negative loading.

When any single load or combination of loads is applied to the balance being calibrated, it will deflect slightly. Under these conditions, the loading struts are no longer orthogonally oriented to the balance. The slight angular displacement of these struts causes appreciable interaction forces to affect the loads being measured in the balance members. To eliminate this condition, a repositioning system is required to restore the balance to the original position it held without load.

Hydraulic Positioning System Continued



Plan View of Sensing System Assembly



Section A-A

Repositioning Cylinder and Balance

BALANCE REPOSITIONING POWER is provided by a set of six hydraulic cylinders, each with an open-center type servo control valve integral with the cylinder body. The control-valve spools are actuated electrically by signals transmitted from small pressure transducers. These sensing units detect pressure changes in each of six air jets impinging upon small flat surfaces (sniffer pads) on the loading block. The centerline of each jet coincides with the centerline of its respective repositioning strut. These air jets escape through a 0.002-in. gap between the end of the jet nozzle and the block.

As a load is applied, the loading block and the balance shift, causing one or more air gaps to be either opened or closed, depending on the direction of the loading. This change in air-gap spacing is reflected as a change in pressure in a small chamber behind the nozzle. This pressure change acts on a diaphragm, which produces a small signal on a strain gage. The signal is then amplified to actuate the servo control-valve spool, which is moved in the direction necessary to cause the hydraulic cylinder affected to reposition the loading block, changing the air gap until it is close to its original or null position. This repositioning action has been effected with an error of ± 0.0002 in. for small loadings and up to ± 0.0005 in. for larger loads. In this way, a stable, null position of the balance is repeated after each loading of any component.

To prevent damage to balances of small capacities certain elements of the load system are fitted with strain gages in such a manner that overloads can cause no harm. The overload circuits for each component can be adjusted for a predetermined maximum load. Under overload, the hydraulic power supply is automatically shut down.

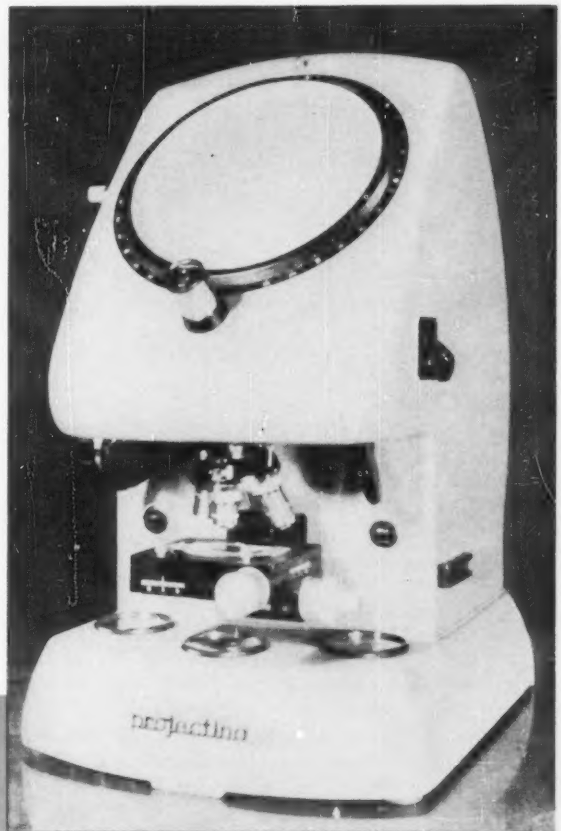
Comparator-Microscope Designed as Multiple-Purpose Projector

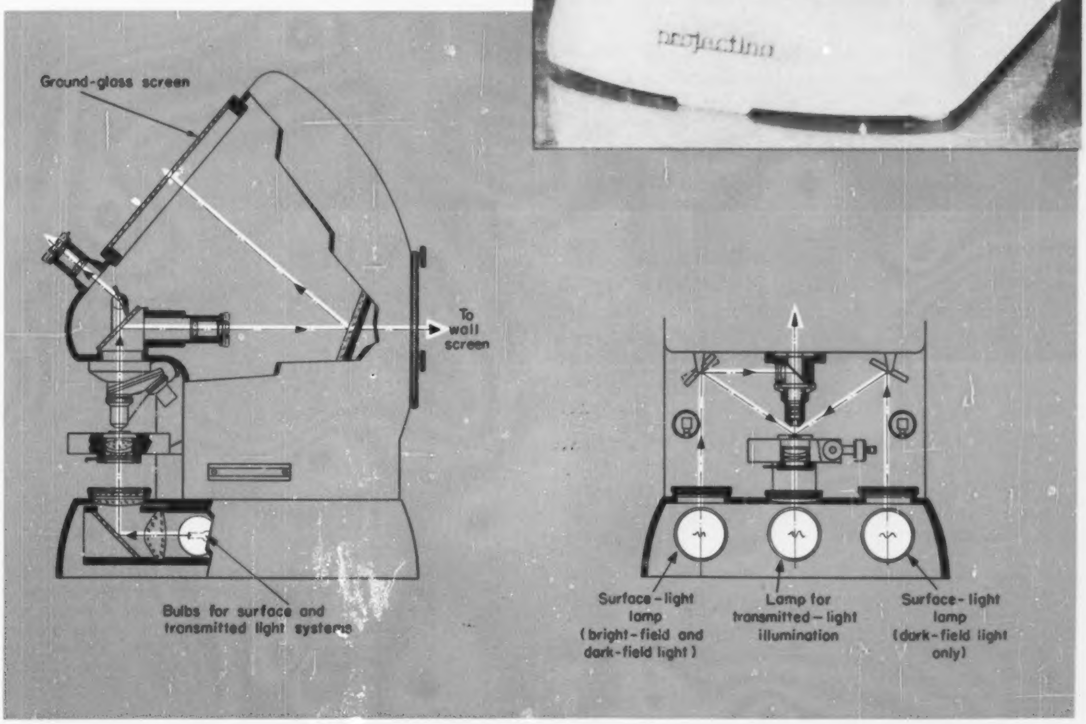
MULTIPURPOSE TESTING INSTRUMENT is designed as a combination microscope, projector, comparator, and camera. Introduced by the Alfred Hofmann and Co., West New York, N. J., the Projectina is a Swiss-perfected precision optical unit which is portable and streamlined in design.

Micropictures may be seen on a 7-in. ground-glass screen and also through the eyepiece, at a constant scale, without refocusing. A single adapter assembly fitted to the observation face of the instrument permits photographing, with certain cameras, any image projected on the ground-glass screen in the magnification range of 7X to 2000X.

THREE BUILT-IN LIGHTS provide good illumination for use of the microscope as well as for transmitted and surface work with bright or dark fields. Light intensity is adjustable by finger-tip control.

Location and angle of inclination of ground-glass screen is chosen to be at the natural level of vision of the operator in a sitting position. For wall projection, a plate on the back of the unit must be removed.





Mechanics of Vehicles—14

PERFORMANCE PREDICTION

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Cleveland

effective power • tractive forces • gradability • passing distance •

PERFORMANCE characteristics that suit a powerplant for use in a wheeled vehicle were surveyed in Part 13.[44] In this, the final article of the series, tentative design choice of powerplant is assumed to have been made, and the problem considered is that of predicting vehicle performance.

Performance calculations are illustrated for two representative vehicles: 1. Passenger car with a manual three-speed gear-shift transmission. 2. Industrial truck incorporating a torque-converter transmission with low and high gear stages. Methods of procedure emphasize calculation techniques and illustrate the advantages of graphical representation of performance results. Specifications for the two assumed vehicles are given in Table 7.

Effective Engine Power: Basic methods for determining effective engine power are identical for both the passenger car and the industrial truck. Power outputs P_o of bare engines at SAE standard air conditions are shown as functions of speed in Fig. 73 and 74. To establish usable power, standard engine power P_o is corrected to existing ambient air conditions. It is important to note that carburetor air-intake temperature under the hood of an engine may be substantially higher than that of the ambient air. The designer may rely on previous experience as a guide in such cases.

For both examples, air-intake temperature is assumed as 140 F, and air pressure is 29.6 in. Hg. Vapor pressure of the air is neglected ($B_v = 0$). From Equation 263 (Part 13), corrected power is

$$P = \frac{P_o(29.6)}{(29.92)}\sqrt{\frac{520}{600}} = 0.925\,P_o \qquad (266)$$

Or, from the correction factors plotted in Fig. 71

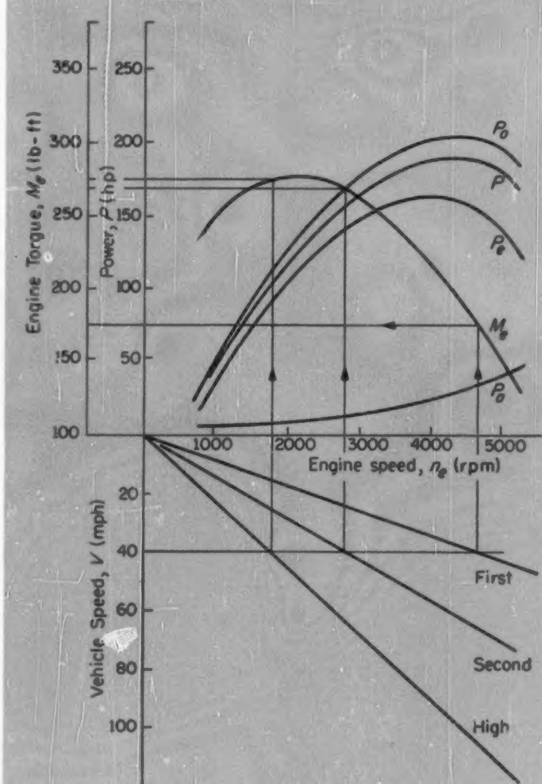

Fig. 73—Powerplant performance characteristics assumed for the passenger-car example. Upper plot shows method for obtaining effective power output P_e from SAE standard power P_o. Lower plot gives relationship between engine speed n_e and vehicle speed V in first, second and high gears.

[44]References are tabulated at end of article.

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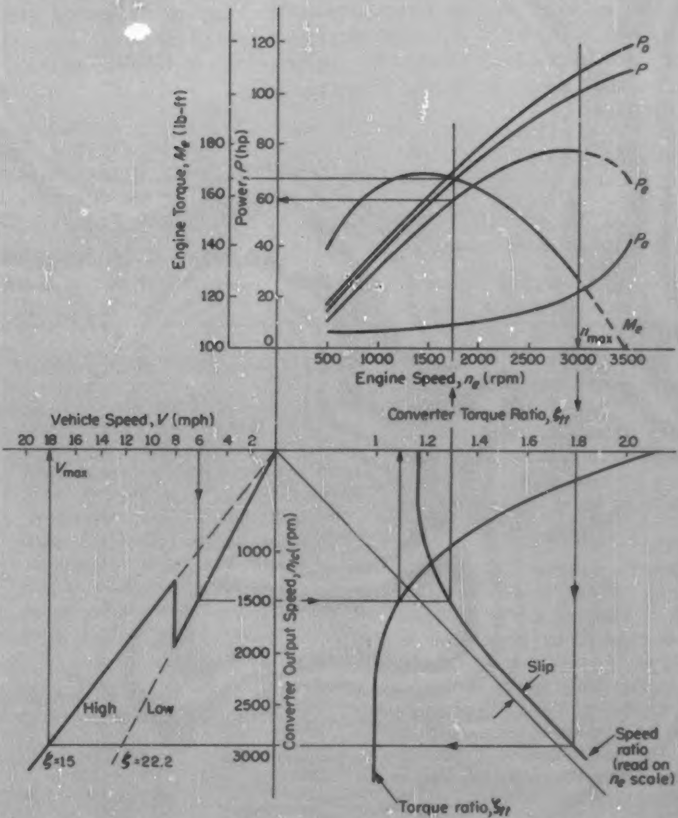


Fig. 74—Powerplant and torque-converter characteristics for the industrial-truck installation. At converter stall speed (n_{tc}= 0), torque ratio peaks at 2.1:1 and engine speed is 1400 rpm. Plot at lower left shows speed reduction in mechanical stages of the transmission. Transition between low and high gear ratios is performed at vehicle speed of 8 mph.

Example: At a vehicle speed of 6 mph, with transmission in the low-gear range, converter output speed is 1490 rpm, engine speed is 1750 rpm, engine torque is 167 lb-ft, and engine power output is 58 hp. Converter torque ratio is 1.1:1.

(Part 13), corrected power is

$$P = 0.93\, P_o \qquad (267)$$

This result confirms the accuracy of the correction diagram and shows that output of the bare engine at existing air conditions is 93 per cent of output under standard conditions.

The corrected power-output curve is found by repeating the foregoing calculation for several P_o values, and then drawing curve P through the points. From the power curve so established, total power consumption P_a of installations and accessories is subtracted graphically, giving the effective engine power P_e actually delivered to the transmission (Fig. 73 and 74). The P_e values are next transformed into torque M_e by use of Equation 261, giving results on which all calculations are based.

Tractive Forces and Limits: Differences in the characteristics of geared and torque-converter transmissions require modification of techniques for calculating tractive forces for the two assumed vehicles. Following sections illustrate the general procedures.

PASSENGER CAR: The gear-shift transmission provides positive ratio coupling between engine speed and vehicle speed, except when the vehicle starts from a standstill. During this part of the operational range, the clutch slips and the exact speed ratio is unknown. After positive drive is re-established, the relationship between engine speed and vehicle speed is

$$V = \frac{2\pi\, n_d\, r}{(12)\,(60)\,\eta_{sl}} \left(\frac{3600}{5280}\right) = \frac{n_e\, r}{168\, \zeta \eta_{sl}} \qquad (268)$$

Terms in this and following equations are defined in Nomenclature.

The tire-slip factor is usually assumed to fall between 0.95 and 0.98. Therefore, with only slight effect on the accuracy of performance calculations, the slip factor can be neglected. Equation 268 can then be simplified to the form

$$V = \frac{n_e\, r}{168\, \zeta} \qquad (269)$$

Graphical solution of Equation 269, shown in Fig. 73, gives engine speed N_e and torque M_e for each gear reduction and road speed. Accuracy obtainable from such graphical solution is in most

cases fully acceptable and saves lengthy numerical calculation.

Transmission and rear-end gear reductions multiply engine torque to the value M_d at the drive axle. Designating the tractive force exerted by the driving wheels on the ground by T, the following relationship applies:

$$T = \frac{12\,M_d}{r} = \frac{12\,M_e\,\zeta\eta}{r} \qquad (270)$$

From this value, the motion-resisting forces encountered in constant-speed driving are next subtracted, giving the free tractive force T_f that is available for grade climbing, trailer pull or acceleration. Following are the principal motion-resisting forces:

1. Rolling resistance R_r, calculated from

$$R_r = Wf$$

can be assumed constant throughout the speed range. If greater accuracy is required, Equations 57 or 58 (Part 5) can be used. In the present example, Equation 57 gives the results tabulated in Table 8.

Table 7—Vehicle Specifications

Passenger Car

WEIGHT DATA: Gross weight of the loaded vehicle is 4000 lb. Distribution of weight to front and rear axles is equal. Height of the cg is $H = 0.25(L)$, where L is the wheelbase.

ENGINE DATA: Bare engine power output P_o is given for SAE standard conditions in Fig. 73. Power P_a consumed by accessories is plotted as a function of engine speed in the same figure.

TRANSMISSION DATA: Transmission is a three-speed, manual-shift unit. Rear-end reduction is through a hypoid gear box. Reduction ratios and efficiencies of the power train are as follows:

	Gear: First	Gear: Second	Gear: High
Transmission ratio	2.6:1	1.6:1	1.1
Rear-end ratio	3.6:1	3.6:1	3.6:1
Total ratio	9.4:1	5.75:1	3.6:1
Total Efficiency	0.85	0.85	0.90

TIRE DATA: Rolling radius of 6.75 x 15 tires is $r = 13.5$ in.

AIR-RESISTANCE DATA: Projected frontal area $A = 28$ sq ft. Coefficient of air resistance $c_a = 0.55$.

Truck

WEIGHT DATA: Gross weight of loaded truck is 15,000 lb.

ENGINE DATA: Bare engine power output P_o at SAE standard conditions is plotted with accessory power consumption P_a in Fig. 74.

TRANSMISSION DATA: Transmission is a torque converter with automatic two-speed gearshift. Ratio between input and output speed and torque multiplication are plotted as functions of output speed in Fig. 74. Torque multiplication at stall speed is 2.1. Additional speed reduction, obtained in the vehicle final-drive gear box is as follows:

	Gear: First	Gear: Second
Reduction	22.2:1	15:1
Total Efficiency	0.85	0.85

TIRE DATA: Rolling radius of 8.25 x 15, 12-ply tires is $r = 15.5$ in.

Table 8—Passenger-Car Performance

V (mph)	n_e (rpm)	M_e (lb-ft)	M_d (lb-ft)	T (lb)	R_r (lb)	R_a (lb)	ΣR (lb)	T_f (lb)	a (ft/sec²)
First Gear									
7	800	230	1840	1650	44	1	45	1605	10.2
10	1150	258	2060	1840	44	4	48	1792	11.4
20	2300	275	2200	1960	44	16	60	1900	12.1
30	3450	240	1920	1710	48	36	84	1626	10.4
40	4600	175	1400	1250	52	64	116	1134	7.3
Second Gear									
11	800	230	1130	1010	44	4	48	962	6.9
20	1400	265	1300	1160	44	16	60	1100	7.9
30	2100	278	1360	1220	48	36	84	1136	8.1
40	2890	265	1300	1160	52	64	116	1044	7.5
50	3500	240	1170	1050	56	100	156	894	6.4
60	4200	200	980	875	64	144	208	667	4.8
70	4900	150	740	660	72	196	268	392	2.8
High Gear									
20	880	240	780	700	44	16	60	640	4.8
30	1320	265	860	770	48	36	84	686	5.1
40	1750	275	890	795	52	64	116	679	5.0
50	2200	278	900	800	56	100	156	644	4.8
60	2630	272	880	785	64	144	208	577	4.3
80	3500	240	780	700	88	256	344	356	2.6
100	4400	190	615	550	120	400	520	30	0.2

Table 9—Truck Performance

V (mph)	n_{tc} (rpm)	n_e (rpm)	ζ_{ts}	ζ_s	ζ_{tt}	ζ_t	M_e (lb-ft)	M_d (lb-ft)	T (lb)	R_r (lb)	T_f (lb)	ζ_γ	γ	m' (lb-sec²/ft)	a (ft per sec²)
Low Gear															
0	0	1400	∞	∞	2.10	46.5	168	6650	5150	300	4850	0	1.03	485	10
2	500	1400	2.80	62	1.60	35.5	168	5100	3950	300	3650	0	1.03	485	7.5
4	980	1500	1.53	34	1.27	28.2	168	4000	3100	300	2800	12	1.1	515	5.4
6	1490	1750	1.17	26	1.10	24.5	166	3460	2680	300	2580	21	1.32	620	3.8
8	1900	2100	1.10	24.4	1.02	22.7	160	3100	2400	300	2100	22	1.40	655	3.2
10	2450	2550	1.04	23	1.02	22.6	150	2820	2180	300	1880	23	1.40	655	2.9
12	2900	3000	1.03	23	1.02	22.6	127	2400	1860	300	1560	23	1.40	655	2.4
High Gear															
0	0	1400	∞	∞	2.1	31.5	168	4500	3480	300	3180	0	1.03	485	6.5
4	680	1450	2.10	31.5	1.46	21.9	168	3120	2420	300	2120	2	1.04	490	4.3
6	1000	1500	1.50	22.5	1.27	19	168	2700	2100	300	1800	7	1.05	493	3.6
8	1360	1650	1.27	19	1.15	17.3	167	2460	1900	300	1600	12	1.10	516	3.1
10	1620	1850	1.14	17.1	1.06	15.9	165	2230	1730	300	1430	14	1.12	525	2.7
12	1960	2120	1.08	16.2	1.02	15.3	160	2080	1610	300	1310	15.3	1.13	530	2.5
14	2250	2350	1.04	15.6	1.02	15.3	155	1970	1530	300	1230	15.3	1.13	530	2.3
18	2930	3000	1.03	15.5	1.02	15.3	127	1620	1250	300	950	15.3	1.13	530	1.8

2. Air resistance R_a, calculated from Equation 64 (Part 6), is

$$R_a = 0.26\, c_a\, A \left(\frac{V}{10} \right)^2 = 0.26(0.55)(28) \left(\frac{V}{10} \right)^2$$
$$= 0.04\ V^2$$

Values of c_a, the air-resistance coefficient, and A, the projected area, are usually known for existing vehicles or, in case of new designs, are assumed on grounds of similarity.

Both R_r and R_a are additively plotted against vehicle speed V and their sum is subtracted from tractive force T. This operation gives the free tractive force T_f, plotted for the passenger car in Fig. 75.

Tractive forces transferable by the driving wheels are limited by available friction, which, in turn, is a function of both the dynamic weight on the driving axle and the frictional properties of the ground (Part 9). For the rear-wheel drive system used on the passenger car, Equation 148, which has the form

$$T_{max} = \frac{\mu W (L_f - fH)}{(L - \mu H)}$$

can be evaluated for representative road surfaces with the following coefficients: $\mu = 0.75$ (dry concrete); $\mu = 0.60$ (gravel); $\mu = 0.40$ (wet asphalt). Weight-distribution data (Table 7) are $L_f = 0.5L$ and $H = 0.25L$. For dry concrete, then

$$T_{max} = \frac{0.75(4000)[0.5 - 0.02(0.25)]}{[1 - 0.75(0.25)]}$$
$$= 1840 \text{ lb}$$

Other traction values are 1410 lb for the gravel surface and 890 lb for wet asphalt. These results are plotted in Fig. 75. The downward trend of the curves with increasing vehicle speed is caused by the decline of μ values at higher speeds (Part 1).

INDUSTRIAL TRUCK: Unlike the geared transmission, which forms a positive coupling between engine and drive wheels, the torque converter is essentially a hydraulic coupling that gives values for torque multiplication and speed reduction that depend on converter speed, Fig. 74.

Torque-Converter Characteristics: Torque ratio of the converter reaches maximum at stall output speed, with a value around 2.2:1. The ratio gradually falls off as output speed increases, the converter eventually acting as a hydraulic coupling with 1:1 torque ratio.

Speed ratio of a torque converter is infinite at stall condition, where the vehicle is stationary and the engine is working at a certain predetermined design speed. As the vehicle begins to move, the engine speeds up, first very slowly, then at an increasing rate until the converter becomes a

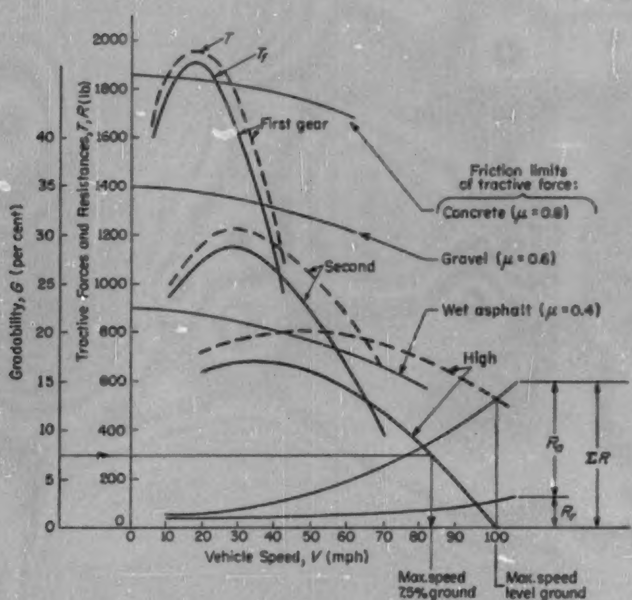


Fig. 75—Tractive force and gradability for the passenger-car example. Free tractive force T_f is obtained by subtracting motion-resisting forces from the gross tractive force T which corresponds to engine effective torque output. Gradability is proportional to free tractive force and therefore can be represented on the same diagram by recalculating the scale.

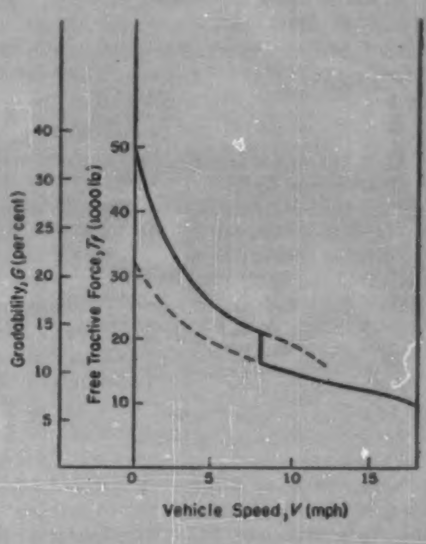


Fig. 76—Free tractive force and gradability as functions of vehicle speed for the truck example.

coupling. Here the proportionality between input and output speeds is re-established. At this point, however, a small difference between input and output speeds remains because of internal slip in the hydraulic element.

Principal advantages of the torque-converter transmission can be summarized as follows:

1. It creates an elastic connection between engine and driving wheels, cushioning the engine from sudden loads and shocks that are unavoidable with gear-shift transmissions.

2. It prevents engine operation at uneconomically low speeds and power outputs.

3. The torque-output characteristic of a torque-converter transmission approaches closely the torque-speed demands of a vehicle.

Characteristics of the converter used in the truck example are given in Fig. 74. When combined with the reduction in the geared stages, the plot leads to a complete graphical equivalence between vehicle speed, engine speed, converter torque ratio, and engine torque output.

Speed and tractive force equations developed in foregoing sections for a geared transmission must be adjusted for use with the torque-converter transmission. The basic relationship, which has a form similar to that of Equation 269, is therefore

$$V = \frac{n_e\, r}{168\, \zeta_{ts}\, \zeta} = \frac{n_e\, r}{168\, \zeta_s} \tag{271}$$

Tractice Forces: Calculation of tractive forces is carried out by means of a modified form of Equation 270:

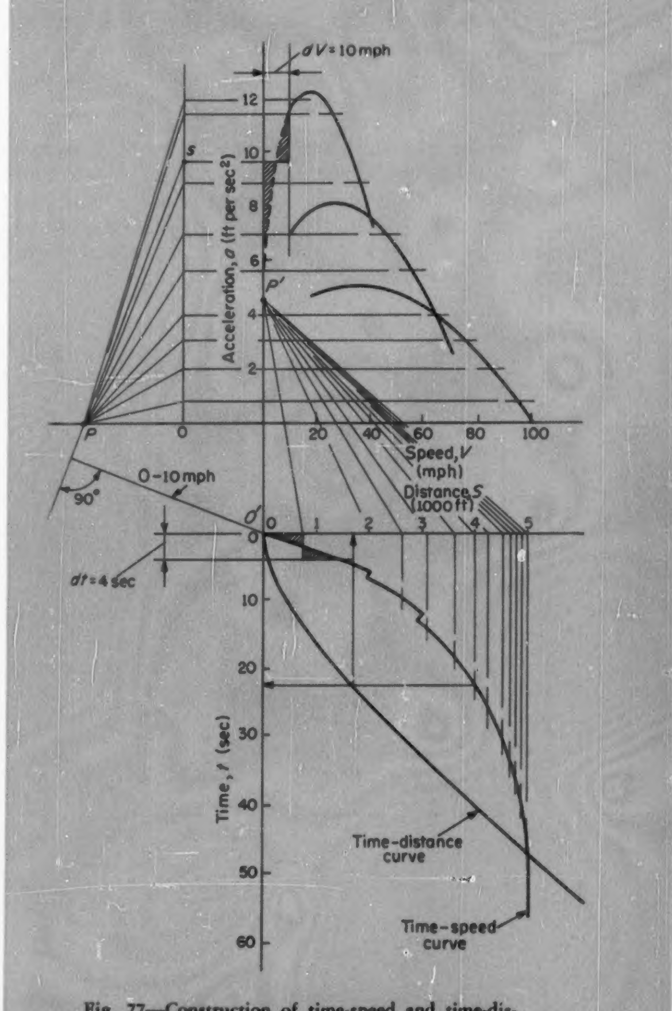


Fig. 77—Construction of time-speed and time-distance curves for the passenger car by graphical integration of the acceleration-speed curve. Diagram interrelates speed, time and distance. For example, a speed of 80 mph is reached in 23 sec over a distance of 1700 ft from the starting point.

Nomenclature

A = Projected vehicle area, sq ft
a = Acceleration, ft per sec^2
B = Barometric pressure, in. Hg
B_o = SAE standard barometric pressure (29.92 in. Hg)
B_v = Vapor pressure of air, in. Hg
c_a = Coefficient of air resistance
f = Coefficient of rolling resistance
G = Grade or gradability, per cent
H = Height of vehicle cg from ground, in.
L_f = Distance between vehicle cg and front axle, in.
M_d = Torque on drive axle, lb-ft
M_e = Engine torque, lb-ft
m = Mass, lb-sec^2-ft^{-1}
m' = Total effective inertia mass, lb-sec^2-ft^{-1}
n = Speed, rpm
n_d = Drive-axle speed, rpm
n_e = Engine speed, rpm
n_M = Engine speed at maximum torque, rpm
n_{max} = Maximum engine speed permissible, rpm
n_{min} = Minimum engine speed, rpm
n_N = Engine speed at maximum power output, rpm
n_{tc} = Torque-converter output speed, rpm
P = Power, hp
P_o = Engine power output at SAE standard air conditions, hp
R_a = Air resistance, lb
R_g = Grade resistance, lb
R_r = Rolling resistance, lb
r = Rolling radius of tire, in.
T = Tractive force, lb
T_f = Free tractive force, lb
t = Time, sec
V = Vehicle speed, mph
W = Vehicle gross weight, lb
ΣR = Summation of motion resistance forces, lb
η = Efficiency factor
η_{sl} = Tire-slip factor
γ = Inertia mass factor of rotating parts
ζ = Total reduction ratio
ζ_s = Total speed ratio
ζ_t = Total torque ratio
ζ_{ts} = Torque-converter speed ratio
ζ_{tt} = Torque-converter torque ratio
ζ_γ = Ratio of change in engine speed to change in vehicle speed
μ = Coefficient of road adhesion

$$T = M_e \zeta_{tt} \zeta \eta \left(\frac{12}{r} \right) = M_e \zeta_t \eta \left(\frac{12}{r} \right) \tag{272}$$

Further steps in the calculation of tractive forces for the truck example are identical with those for the passenger car. Sum of resistance forces is subtracted from the gross tractive force (Equation 272), giving free tractive force T_f. For the industrial vehicle in this example, which usually operates at speeds below 25 mph, air resistance is neglected. In the calculation of rolling resistance, the assumed coefficient $f = 0.02$ is considered as speed-independent for the relatively narrow operating-speed range. Results of such calculations are given in Table 9.

Gradability: Free tractive forces, calculated for both the passenger car and the truck, can be used to obtain values of grade the vehicles can negotiate at constant speed. From Equation 61 (Part 5),

$$G = \frac{100\, T_f}{W} \tag{273}$$

The graphical representation of T_f can also be directly transformed into corresponding gradability values, since T_f and G are related by the equation

$$T_f = R_g = \frac{WG}{100} \tag{274}$$

Maximum speed obtainable on each particular grade is then graphically determined at the intersections of the grade grid lines with the free tractive force curve, Fig. 75 and 76. Limits set by available friction naturally determine maximum gradability.

Table 10—Mass Factors

Gear	Total Ratio ζ	Mass Factor γ	Effective Mass m' (lb-sec²-ft⁻¹)
First	9.4	1.26	157
Second	5.75	1.12	140
High	3.6	1.07	134

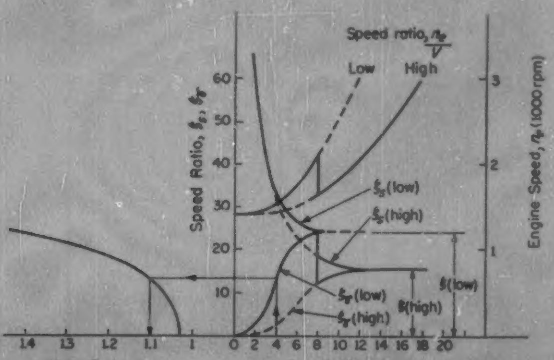


Fig. 78—Determination of inertia mass factor γ for the torque-converter transmission. Overall speed ratio ζ_s decreases from ∞ at converter stall speed ($V=0$) to the mechanical-stage ratios ζ (low) and ζ (high) when the converter acts as a coupling. The actual relationship between engine speed and vehicle speed is given by the n_e/V curves. Inertia effect of rotating engine parts is proportional to dn_e/dV, which is represented by tangents to the n_e/V curves. The ζ_γ curve, constructed by measuring tangent slopes, gives values ranging from zero at $V=0$ to the values ζ (low) and ζ (high). At the left side of the plot, γ is shown as a function of the ratio ζ_γ.

Acceleration: To determine acceleration, use is made of the basic equation of vehicle motion

$$am\gamma = T - \Sigma R \tag{275}$$

where γ is the factor expressing the effect of rotating parts, and ΣR is the sum of resistances in constant-speed vehicle motion. Free tractive force is defined as

$$T_f = T - \Sigma R \tag{276}$$

Substituting Equation 276 into Equation 275,

$$a = \frac{T_f}{\gamma m} = \frac{T_f}{m'} \tag{277}$$

Here, m' is the effective mass to be accelerated and $m' = \gamma W/g$.

PASSENGER CAR: Value of the factor γ is obtained from Equation 86 (Part 6), which has acceptable accuracy for all road vehicles:

$$\gamma = 1.04 + 0.0025\, \zeta^2 \tag{278}$$

The first term expresses the contribution of the vehicle wheels, and the second term the contribution of parts rotating at engine speed, which is related to wheel speed by the reduction ratio ζ. Results obtained when Equation 278 is evaluated for the passenger car are listed in Table 10.

As a final step, free tractive force T_f is divided by values of the effective mass m', giving acceleration a. Results are plotted in Fig. 77 as functions of vehicle speed. Results of calculations are also given in Table 8.

INDUSTRIAL TRUCK: Corresponding calculations giving acceleration for the torque-converter installation follow basically the same steps as for the passenger car. The one exception is that the reduction-ratio value substituted into Equation 86 for determination of the factor γ is not the speed ratio ζ_s of the transmission. Explanation of this behavior of the torque converter is that vehicle speed is not directly proportional to engine speed. This effect can be clearly observed from the speed-ratio curves in Fig. 74 and 78, where translatory speed-up of the vehicle is accompanied by almost no change in engine speed (curves a and b), especially in the low-speed range. At the same time, the total speed ratio ζ_s is very high.

The ratio value substituted into Equation 86 must express change in engine speed Δn_e in relation to change in vehicle speed ΔV, and therefore

a new ratio is introduced. It is defined as

$$\zeta_\gamma = \frac{dn_e}{dV}$$

and is shown graphically in Fig. 78. When the torque converter begins to act as a hydraulic coupling at high speeds, engine and vehicle speeds again become directly proportional, as in the case of the gear-shift transmission. Consequently, $\zeta_\gamma = \zeta_s$.

For the truck in this example, where an extremely heavy vehicle is powered by a relatively small engine, the constants of Equation 86 must be adjusted. As a rough approximation,

$$\gamma = 1.03 + 0.0006\,\zeta_\gamma^2 \qquad (279)$$

Results of these calculations are shown as functions of ζ_γ in Fig. 78. Values of γ can be taken directly from the plot for any vehicle speed. Finally, acceleration is calculated from Equation 277. Complete results are given in Table 9 and plotted in Fig. 79.

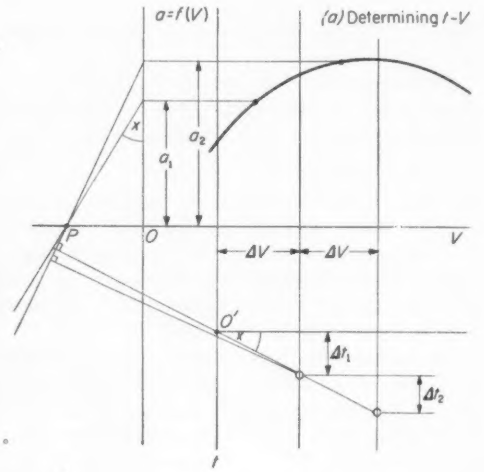
Time-Speed Relationships: In Fig. 77 and 79, calculated values of maximum acceleration for the car and the truck are plotted against vehicle speed. Acceleration, however, is not entirely suitable as a factor for illustrating vehicle performances. Time-speed and time-distance relationships

Table 11—Graphical Integration

Problem: By graphical means, determine the time-speed relationship represented by Equation 281. The technique requires solution of the equation

$$\Delta t = \frac{\Delta V}{f(V)} = \frac{\Delta V}{a}$$

where the curve $f(V)$ vs. V is given.



From similar triangles in a,

$$\frac{\Delta t_1}{\Delta V} = \frac{OP}{a_1} \text{ or } \Delta t_1 = \frac{(OP)\Delta V}{a_1}$$

$$\frac{\Delta t_2}{\Delta V} = \frac{OP}{a_2} \text{ or } \Delta t_2 = \frac{(OP)\Delta V}{a_2}$$

The graphical construction, illustrated for increments Δt_1 and Δt_2, is repeated for the velocity range of interest. Then,

$$t = \Sigma \Delta t = \Delta t_1 + \Delta t_2 + \ldots . + \Delta t_n$$

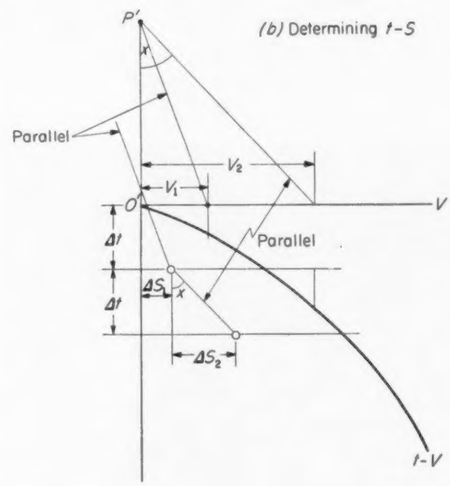
Solution to Equation 281, which is the time-speed relationship, is obtained by fairing a curve through the graphically determined points.

Problem: Determine the time-distance relationship by graphical integration of the time-speed relationship.

The incremental equation is

$$\Delta S = V \Delta t$$

where the curve of V vs. t is given in b.



From similar triangles,

$$\frac{\Delta S_1}{\Delta t} = \frac{V_1}{O'P'} \text{ or } \Delta S_1 = \frac{V_1\,\Delta t}{O'P'}$$

$$\frac{\Delta S_2}{\Delta t} = \frac{V_2}{O'P'} \text{ or } \Delta S_2 = \frac{V_2\,\Delta t}{O'P'}$$

Therefore,

$$S = \Sigma \Delta S = \Delta S_1 + \Delta S_2 + \ldots . \Delta S_n$$

A line faired through the points represents the required solution.

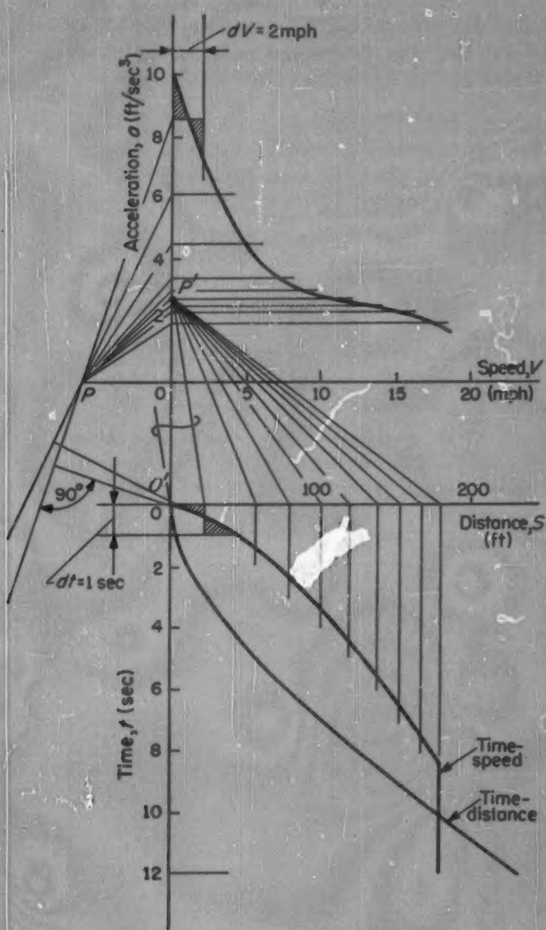


Fig. 79—Construction of time-speed and time-distance curves for the truck example. Techniques are the same as those used in construction of Fig. 77. Acceleration values in this case do not reach zero since maximum engine speed is limited by an engine governor.

offer more information.

Calculations for these relationships are based on the equation for accelerated motion, which in differentiated form is

$$\gamma m \left(\frac{dv}{dt} \right) = T - \Sigma R = T_f \tag{280}$$

Consequently,

$$dt = \frac{\gamma m (dv)}{T_f}$$

Unfortunately, free tractive force T_f is itself a function of V, which makes the equation relating time and speed not integrable by conventional methods. Form of the equation is

$$t = C \int_{V_2}^{V_1} \frac{dV}{[f(V)]} \tag{281}$$

where units of V are mph.

The graphical method of integration offers a solution with sufficient accuracy. Theory of graphical integration is not detailed here.[45] However, techniques are demonstrated for the car and truck examples, using values plotted in Fig. 77 and 79. Graphical basis of the technique is illustrated in Table 11. Outline of procedure is as follows:

1. On the plot representing acceleration as a function of vehicle speed V, the area between the acceleration curve and the speed axis is divided into small sections to represent the differential dV (Fig. 77).

2. A rectangle of width dV is constructed with area equal to that enclosed under the curve proper (shaded areas equal).

3. Height of this rectangle is then projected on the acceleration axis (or a line parallel to it), and the point thus created is connected by a straight line with the integration pole P.

4. From this line, a perpendicular is erected to the speed-time co-ordinate system. The first such perpendicular is drawn through the zero-zero point to intersect the ordinate at 10 mph extended from the upper diagram. This gives a point on the time-speed curve. The second perpendicular, corresponding to the interval from 10 to 20 mph, is drawn through the point just located and extended to meet the 20-mph ordinate. This process is repeated until zero acceleration and maximum speed are reached. The result is a complete graphical representation of the time-speed relation.

5. On the points where gears are changed, the power connection to the engine is interrupted, and the vehicle is decelerated by rolling and air resistances. An accurate determination of the speed-time relation during this part of the vehicle progress was shown in Part 12 of this series. Gearshift time is usually between 1 and 2 seconds.

6. Distance of the pole P from point O is determined by the graphical scales used for the three variables involved. The relationship giving PO in length units is

$$PO = \frac{\text{(speed scale)}}{\text{(time scale) (acceleration scale)}} \tag{282}$$

where units of length chosen for the construction must be consistent for all scales.

In construction of the time-speed diagram for the passenger car, Fig. 77, $dV = 10$ mph, $dt = 4$ sec, and evaluation of Equation 282 gives

$$PO = \frac{10(1.47)}{4(1)} = 3.68 \text{ (length units)}$$

In this equation, the factor 1.47 converts the speed scale (mph) to the same units as the acceleration scale (ft per sec^2).

Similarly, evaluation of Equation 282 for the truck (Fig. 79) gives the result

$$PO = \frac{2(1.47)}{1(1)} = 2.94 \text{ (length units)}$$

Time-Distance Relationships: Graphical integra-

tion of the t-V curve gives the time-distance relationship. Form of the equation for the t-V curve is

$$s = \int_{t_2}^{t_1} V[f(t)]dt \tag{283}$$

The method of integration is as follows:

1. The diagram representing the relation between time t and speed V is considered to be known. The fields under curves in Fig. 77 and 79 are again divided into small sections representing the differential dt.

2. A rectangle of width dt is then constructed with an area equal to that enclosed between the curve and the t axis (shaded areas equal).

3. Height of this rectangle is projected to the distance and speed axis, and the point thus created is connected with integration pole P'.

4. A line parallel to the connecting line determines the time-distance curve for that particular section of dt, since it represents the integral of Equation 283. This process is repeated until the range of maximum (constant) speed is reached; here the distance progress becomes a straight line.

5. The distance of the integration pole $P'O'$ is found (as for the time-speed calculation) from the scales of the variables. The relationship is

$$P'O' = \frac{\text{(distance scale)}}{\text{(speed scale) (time scale)}} \tag{284}$$

Evaluation of Equation 284 gives $P'O'$ for the passenger car (Fig. 77) as

$$P'O' = \frac{500}{10(1.47)(4)} = 8.5 \text{ (length units)}$$

Similarly, pole distance for the truck example (Fig. 79) is

$$P'O' = \frac{20}{2(1.47)(1)} = 6.8 \text{ (length units)}$$

Accuracy of graphical integration depends on the size of the differential sections. Acceptable results are reached, however, with fairly large sec-

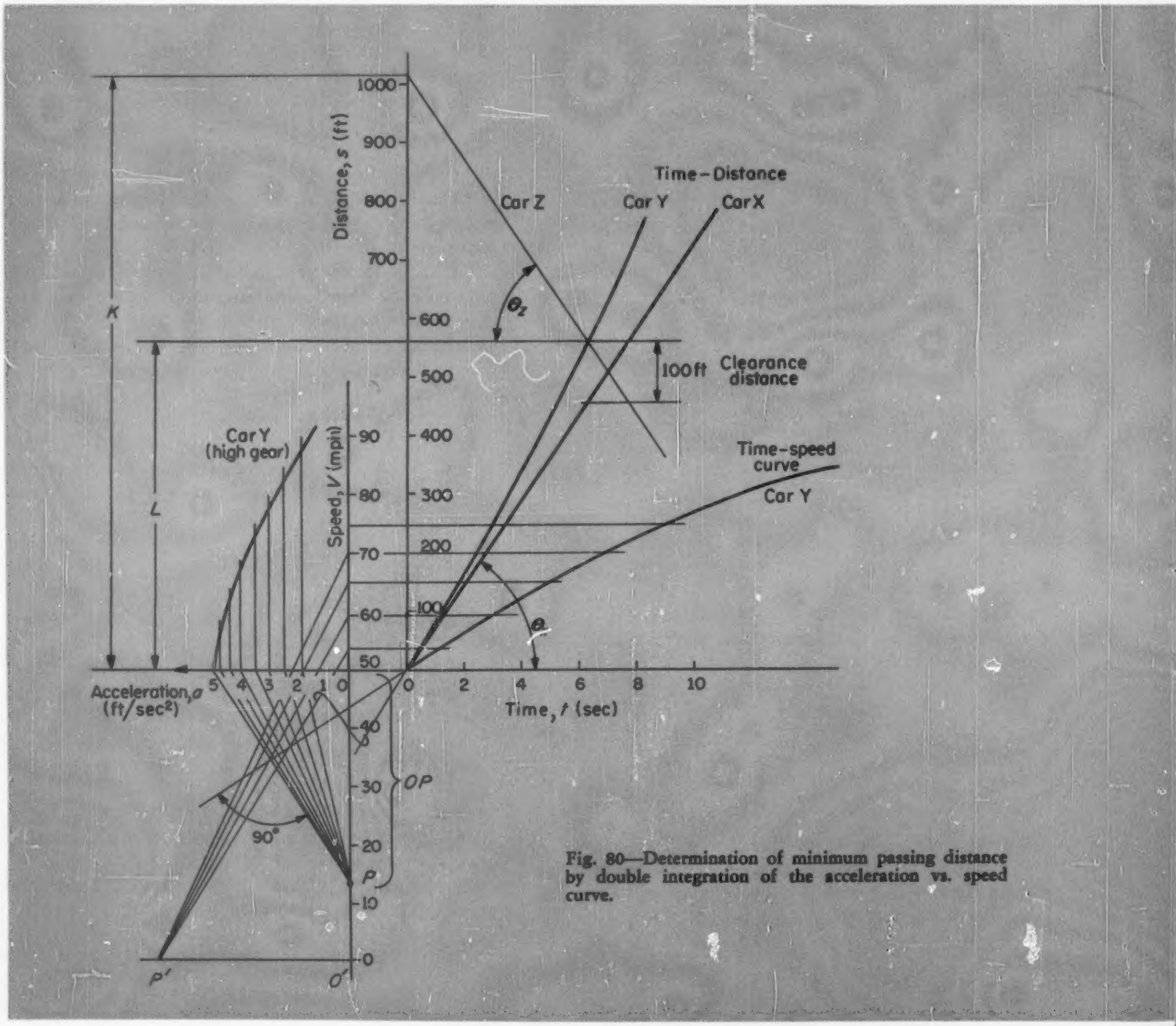


Fig. 80—Determination of minimum passing distance by double integration of the acceleration vs. speed curve.

tions. Curves, which in the first stages of construction are multiple broken lines, are finally faired into smooth curves.

Passing Distance: Time-distance curves can be used for graphical determination of distances required for passing. The technique is shown in Fig. 80, which solves a situation involving three cars:

CAR X: Car X is traveling at constant speed of 50 mph, represented by the line with slope θ_x.

CAR Y: Car Y is the car considered as an example in this article and is traveling in third gear at a constant 50 mph. At time zero, the throttle is suddenly opened wide, and the car begins to accelerate.

CAR Z: The third car is approaching from the opposite direction at a constant speed given by the line under angle θ_z. In this example, speed of Z is also taken as 50 mph.

The acceleration vs. speed characteristic of car Y in high gear is taken from Fig. 77 and is shown in the auxiliary diagram on the left of Fig. 80. Only the part above 50 mph, which is required for this calculation, is shown.

The first graphical integration, based on the principles explained in earlier sections, delivers the auxiliary time-speed curve. The pole distance *PO* is given by Equation 282 as

$$PO = \frac{5(1.47)}{1(1)} = 7.34 \text{ (length units)}$$

The time-speed curve is again integrated, delivering the time-distance curve of the car Y. The pole distance *P'O'* of this integration is determined from Equation 284 as

$$P'O' = \frac{50}{5(1.47)(1)} = 6.8 \text{ (length units)}$$

If the minimum clearance distance required before the car Y can pull back into its own line is 100 ft, minimum free distance for passing is $L = 560$ ft.

In case, however, car Z is approaching from the opposite direction, it can safely pass abreast of car Y at the minimum distance *L*, that is, after car Y has pulled back into line. The minimum distance *K* between cars Y and Z at time zero is taken from the diagram as 1020 ft.

The advantage of such a graphical presentation is that it permits the effects of different speeds to be determined without repeated calculations.

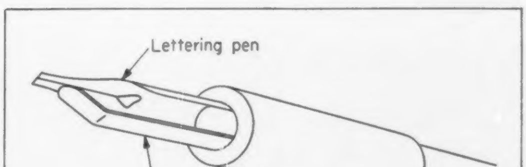
REFERENCES

44. Preceding articles in the ***Mechanics of Vehicles*** series by Jaroslav J. Taborek and the MACHINE DESIGN issues in which they appeared were as follows:
    Part 1—"Motion of Wheels" ..... May 30, 1957
    Part 2—"Cornering and Directional Control" ..... June 13, 1957
    Part 3—"Steering Forces and Stability" ..... June 27, 1957
    Part 4—"Stability on a Curve" ..... July 11, 1957
    Part 5—"Motion-Resisting Forces" ..... July 25, 1957
    Part 6—"Resistance Forces" ..... Aug. 8, 1957
    Part 7—"Center of Gravity" ..... Aug. 22, 1957
    Part 8—"Longitudinal Stability" ..... Sept. 5, 1957
    Part 9—"Limits of Vehicle Performance" ..... Sept. 19, 1957
    Part 10—"Performance Limits" ..... Oct. 17, 1957
    Part 11—"Dynamics of Braking" ..... Nov. 14, 1957
    Part 12—"Braking Performance Limits" ..... Nov. 28, 1957
    Part 13—"Powerplant Characteristics" ..... Dec. 12, 1957
45. Hutte—***Mechanics***, Part 1, W. Ernst Verlag, Berlin, 1955.
46. Lavender, Webb—"Acceleration," ***Automobile Engineer***, London. 1953.
47. J. L. Koffman—"Performance Prediction," ***Automobile Engineer***, London, Sept., 1954.
48. J. L. Koffman—"Vehicle Performance," ***Automobile Engineer***, London, Dec., 1955.
49. Symposium—"Where does all the Power Go?," ***SAE Transactions***, 1956:
    C. E. Burke, L. H. Nagler—"The Engine, the Power Source."
    E. C. Campbell—"The Accessories, the First Bite."
    W. E. Zierer, H. L. Welch—"Effective Power Transmission."
    T. D. Kosier, W. A. McConnell—"What the Customer Gets."

Tips and Techniques

Ink Reservoir

An ink-holding reservoir for a lettering pen can be easily made. A piece of brass strip is cut from a paper fastener or a piece of brass shim and bent

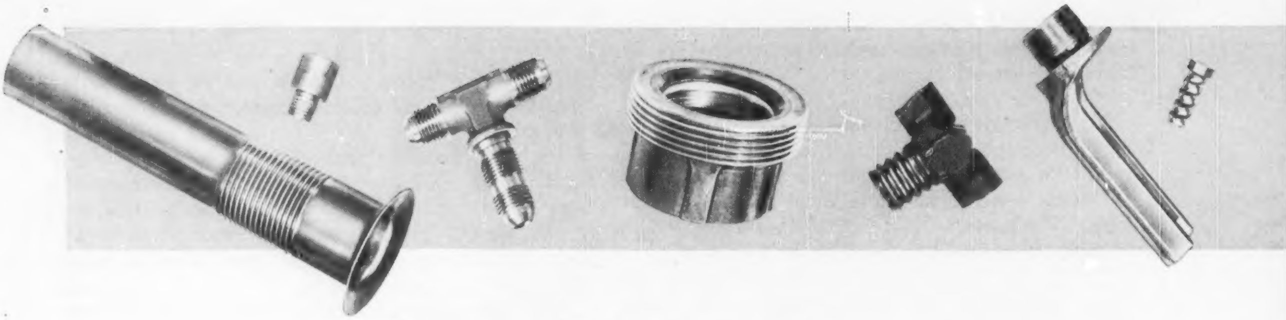


at one end. The strip is inserted into the penholder, with the curved end of the strip touching the nibs of the pen. Moving the end of the strip closer to the pen point increases the rate of feed.—GEORGE D. FERRELL, *designer, Wright Machinery Co., Div. of Sperry Rand Corp., Durham, N. C.*

Adding on Slide Rule

Occasionally, in sliderule computations, numbers must be added. This can be done directly on the sliderule, eliminating errors in reading and speeding up the job.

Given two numbers, *a* and *b*, when $a < b$. Opposite *b* on the D scale, set *a* on the C scale. The quotient will appear under the index. Set the index to a value one greater than the quotient. Under *a* on the C scale, the sum will appear on the D scale.—JESSE ROTH, *electrical engineer, Curtiss-Wright Corp., Carlstadt, N. J.*



How to Design for

THREAD ROLLING

ROLLED threads have high strength, accuracy, and excellent surface finish. They are uniformly produced at high rates of production with no material waste. Cold working of the surface increases tensile strength up to 10 per cent. When a thread is rolled, fibers of the material are not severed as in other methods of screw-thread production, but are reformed in continuous unbroken lines following thread contours, Fig. 1. Rolled threads resist stripping because shear failures must take place across, rather than with, the grain.

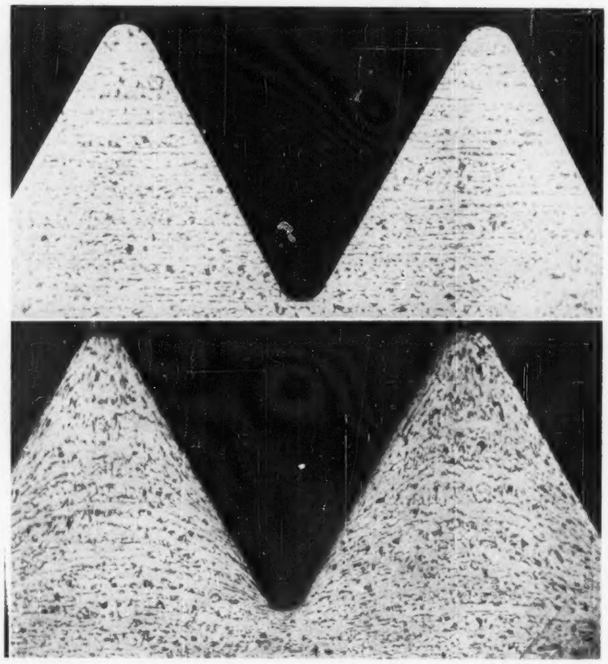
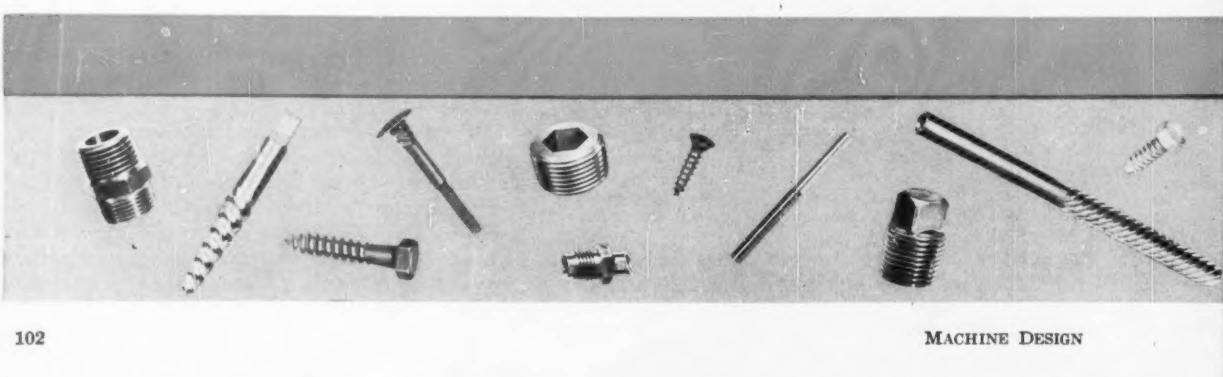


Fig. 1—Rolled threads, bottom, are forged to give unbroken grain flow into the thread form, resulting in greater strength than with cut threads, top

Rolling between dies leaves the thread with smooth burnished roots and flanks, free from tears, chatter, or cutter marks that can serve as focal points of stress and, therefore, starting points for fatigue failures. Rolling also leaves surface layers of the thread, particularly in the roots, stressed in compression. These compressive stresses must be overcome before tensile stresses can build up to cause fatigue failures.

Rolled threads increase in hardness at the root up to 10 Rockwell C points on parts treated to Rockwell C 30. This increase in root hardness, up to 30 per cent, adds considerably to resistance to fatigue. Improved fatigue strength is from 50 to 75 per cent. On heat-treated bolts from Rockwell C 36 to 40 hardness, that have threads rolled after



Only by being familiar with production processes can a designer develop parts that serve their functional requirements yet are practical and economical to manufacture. This article is the first of a series of three that form a comprehensive design manual on thread rolling, knurl, spline, and serration rolling, and selection of materials for the process. The articles are based on chapters of *Engineering Data on Thread and Form Rolling*, to be published soon by Reed Rolled Thread Die Co., Worcester, Mass.

heat treatment, tests show increased fatigue strength of 5 to 10 times that of cut threads.

Material Savings: Where blanks are prepared by heading, extruding or stamping, or where the thread is the largest diameter on the part (as a stud), rolling will save material because no chips are produced in rolling. The blank is made smaller than the finished thread and material pressed out of roots of the thread is rolled up to form the crests.

This forging results in savings, Table 1, ranging from about 16 per cent on larger-diameter threads to over 27 per cent on smaller-diameter threads.

Table 1—Material Saved by Thread Rolling

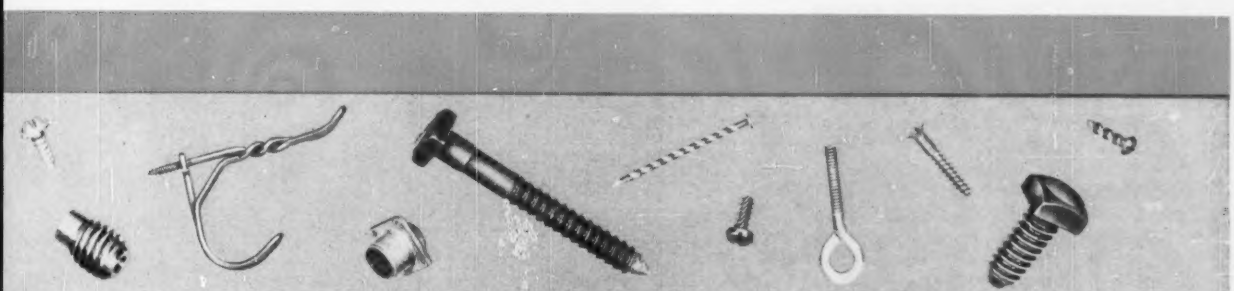
Thread Size	Saving (per cent)
8-32	24
¼-20	25
⅜-16	27
½-13	19
⅝-11	19
¾-10	16
1-8	18
1¼-7	16
1½-6	16

On stampings, thickness of metal from which the stamping is made can often be reduced. This also reduces weight of the scrap strip or sheet from which the stamping is made.

Accuracy and Uniformity: Production of accurate threads normally requires close control over pitch diameter, thread angle, lead, taper, roundness, and drunkenness, Fig. 2. There are a number of reasons why it is inherently easier to achieve accuracy on pitch diameter, thread angle, lead, and taper by rolling than by other processes and, what is often equally important, to maintain that accuracy over long periods. Control over roundness and drunkenness, while no easier to maintain than by other processes, can be done by the average operator.

DIAMETERS: Major, pitch, and minor diameters depend upon blank diameter, thread form of dies, and setup and rigidity of equipment used. Controlling diameter of plain cylindrical blanks within close tolerances is relatively easy and economical, either by using carbide dies if the blanks are cold-forged or cold-drawn, or by turning, shaving, or centerless grinding if blanks are made from bar stock. Modern thread-rolling machines are rugged and easily adjusted, so all diameters are readily controlled.

Tolerances specified for pitch diameter include



all errors of pitch diameter, lead, and angle. Taper on pitch diameter depends upon straightness of blank and machine setup, both easily controlled. Accuracy and lead depend on accuracy and setup of dies and the material being rolled. In most cases, lead of thread on the die is exactly reproduced on the material rolled. However, some types of harder and stiffer materials have a tendency to "spring back" after rolling, with the result that lead on the work may be contracted a very small amount. In such cases, dies with expanded lead may be used to produce a uniform thread of correct lead.

Control of drunkenness, Fig. 2, depends upon using dies with correct lead angles and upon careful matching and proper feeding. Roundness is dependent upon roundness and uniformity of hardness of the blank, and upon rate of application and release of die pressure. If dies are designed and set up properly, close tolerances on roundness may be steadily maintained.

UNIFORMITY: If sufficient care is used, extremely accurate threads can be reproduced by any of the common threading methods, but rolling is unique in its inherent ability to maintain accuracy of original setup during long runs of high-speed production. Thread form of a set of thread-rolling dies is faithfully reproduced on the parts and does not change appreciably during entire life of the dies. Thread-rolling dies do not wear out in the same manner as do other threading tools. Wear, instead of being concentrated on a sharp cutting edge, is distributed over a broad surface, and the rolling action is relatively free from friction. Therefore, thread form of a rolling die is not changed by erosion, nor does it fail to reproduce itself because of dullness or adhesion. It cannot be altered by improper sharpening, since sharpening is never required.

Smooth Finish: In cold-forming operations, surface finish on the work is a close approximation of surface finish of the dies. This holds true for thread rolling except that threads produced are ordinarily smoother than the dies or rolls. This

Nomenclature

C = Diameter at end of blank, after chamfering
E_o = Diameter, small end of tapered blank, before chamfering
F_{cs} = Width of crest flat, external thread
h = Height (depth) of thread, average
K = Minor diameter of thread
n = Threads per in. (tpi)
p = Thread pitch
R = Rolling diameter
t = Thickness of thread at minor diameter, $2h \tan \alpha + F_{cs}$
V_1 = Volume of 1-in. length of minor diameter
V_2 = Volume of 1-in. length of thread
x = Distance from root of thread to center of gravity of thread form, $(h/3)[(2F_{cs} + t)/(F_{cs} + t)]$
α = One-half the thread angle

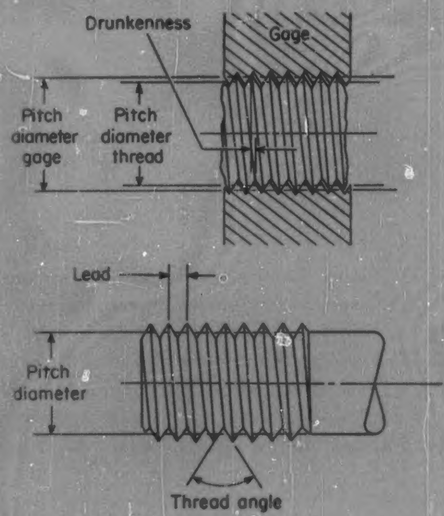


Fig. 2—Screw-thread terms, as used in this article

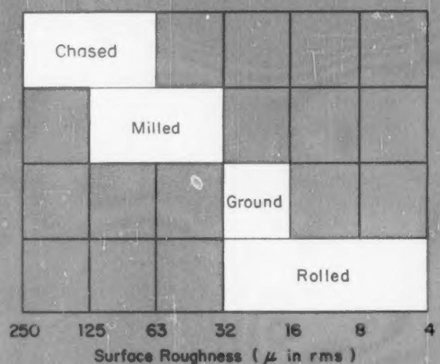


Fig. 3—Comparison of screw-thread surface finishes produced by various processes

Fig. 4—Left-hand threads can be rolled as readily as right-hand—frequently simultaneously

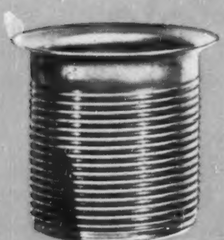


Fig. 5 — Thin-wall hollow parts are roll threaded by crimping entire wall

Fig. 6—Due to ductility of material used, stampings are ideal for roll threading

Fig. 7 — Rolling easily produces knurls, splines, and serrations

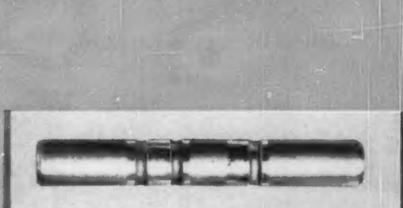


Fig. 8—Rolled oil grooves are popular due to their low cost and smooth finish

improvement is from slight slipping and burnishing that the thread always receives as it rolls against the dies. By using carefully ground and polished dies and smoothly finished blanks, the ultimate in smooth, burnished threads can be attained, Fig. 3.

Speed and Economy: Rolling has long been conceded to be the fastest method of producing screw threads. Thread-rolling machines may be manually loaded or arranged with semiautomatic or completely automatic feeding devices, with several machines to each operator. Although thread rolling has proved economical on large quantity production, similar savings and economies are realized on small-lot production.

Threads may be rolled on automatic screw machines without reducing spindle speeds. Since rolling can be done on the collet end of the part, behind a shoulder, a secondary threading operation is frequently avoided.

▶ Applications

Thread rolling is a versatile process capable of forming a wide variety of threads on many different materials and, in addition, capable of performing several nonthreading operations such as formation of knurls, serrations, splines, etc. All commonly used thread forms can be produced by rolling.

Left-hand Threads, Annular Rings and Multiple Threads: By using suitable dies and making no other change in setup or operation, it is possible to roll left-hand threads, annular rings, or multiple threads, Fig. 4.

Piloted and Step Threads: Fasteners with two or three undersized threads on outer end to serve as a pilot, or several oversized threads on inner end to serve as a locking device, can be rolled in a single operation.

Rolling Chamfer During Threading: Under certain conditions, ends of blanks can be slightly chamfered or beveled during thread rolling.

Tapered Threads: Either front or back-taper threads can be easily rolled by adjusting dies regularly used for straight threads.

Hollow Parts: Threads on hollow cylinders can be rolled either by forging the thread in the usual manner (if the wall is thick enough) or by crimping the entire wall when it is very thin, Fig. 5. However, crimped threads must be formed over a threaded mandrel and unscrewed after forming.

Stamped Parts: Threads on metal stampings can be rolled easily due to ductility of the material used, Fig. 6. In many instances, thinner metal can be used because outside diameter of the portion to be threaded need only be the approximate pitch diameter of the thread, without making any reduction to cor-

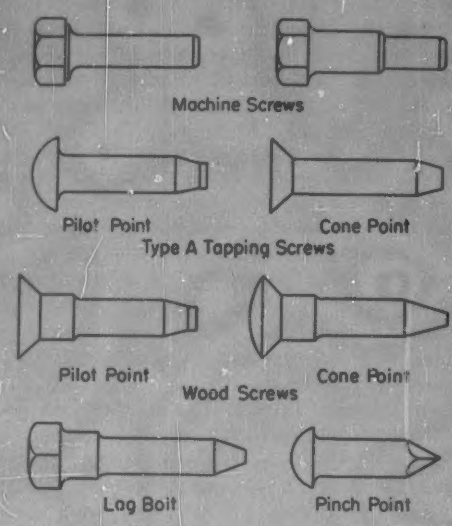


Fig. 9—Typical cold-formed blanks for common fasteners—before thread rolling

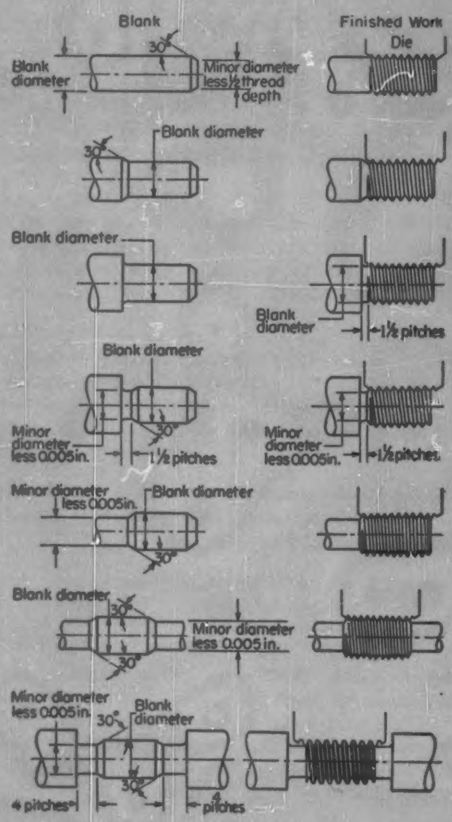


Fig. 10—Recommended blank design for rolled threads, showing use of necked areas to provide maximum thread length

responding inside diameter of the stampings.

Screw and Washer Assemblies: Manufacturers of screws that have washers assembled under the heads take advantage of the increase in diameter of threads when rolled to keep the washers from falling off. Washers are usually assembled automatically on the blank during thread rolling.

Simultaneous Threading and Fluting: Flutes and threads of self-tapping and special screws are frequently rolled simultaneously.

Knurling, Splines and Serrations: Thread rolling machines produce straight, diagonal, and diamond knurling, and involute splines and serrations, Fig. 7.

Oil Grooves: Rolled in the surfaces of shafts before the final operations, oil grooves have proved very satisfactory because of low cost and smooth finish, Fig. 8.

Nonuniform Leads: It is possible to roll threaded parts with pilot threads that are axially displaced a few thousandths from helical continuity with the rest of the threads.

Burnishing: Thread-rolling machines fitted with flat or formed dies are used to burnish parts that have been preformed on lathes or screw machines.

Irregular Shaped Parts: Since it is unnecessary to grip the part in any holding device during rolling, thread rolling easily threads irregular-shaped parts.

Threading Close to Shoulders: Although dies usually have small bevels to prevent breakage along the edge, it is possible to secure them with blunt starts to produce a full thread close to a shoulder.

Long Threads: While most thread rolling is done by the in-feed method (entire length of thread is formed simultaneously), machines can be adapted to through-feed long lengths of thread.

Sizes Rolled: Diameters from 0.060 to 4½ in. can be readily rolled on existing equipment. Threads per inch ranging from 2 to 80 are commonly rolled, and dies for both finer and coarser threads can be produced.

Materials Rolled: Practically all commonly used carbon and alloy steels, including stainless and tool steels, are regularly threaded by the rolling process. Nonferrous metals including brass, bronze, aluminum, cop-

Table 2—Blank Diameters for Straight Threads

Material	Hardness (Rockwell C)	Amount to Add to Minimum Pitch Diam (% of pitch-diam tolerance)
Aluminum alloys	Soft	30 to 50
	Hard	20 to 40
Brass and bronze		20 to 40
Steel, 10 to 15% carbon	Soft	0 to 20
30 to 50% carbon	Soft	20 to 40
30 to 50 C or Alloy	15 to 25	30 to 50
30 to 50 C or Alloy	26 to 32	40 to 60
30 to 50 C or Alloy	33 to 40	50 to 70
Stainless, chrome-nickel (300 series)		60 to 80
Stainless, chrome (400 series)		40 to 60

per, beryllium copper, titanium, nickel, silver, gold, monel, Everdur, and some die-casting alloys are also rolled in regular production runs. Experiments have shown that nonmetallic materials, including some plastics, can be successfully threaded by rolling.

Threading Hard Blanks: Thread rolling is feasible on practically all malleable materials of hardnesses through Rockwell C 40, and in some instances higher. Dies will produce several million pieces per setting on soft ductile materials but down to only a few thousand pieces per setting on harder, heat-treated, or less ductile materials.

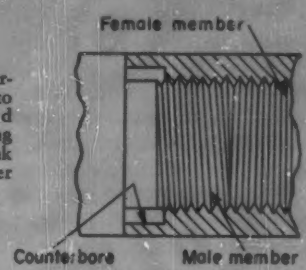


Fig. 11 — Counterbore at entrance to internal thread eliminates necking operation on blank and gives greater strength

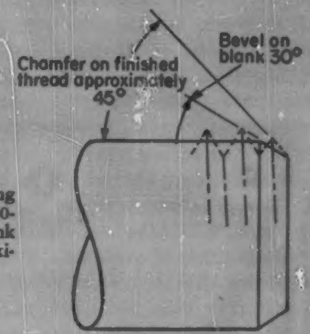


Fig. 12 — Rolling pressure forces 30-deg bevel on blank out to approximately 45 deg

▶ Blank Specifications

Since rolling does not remove or compress material, the blank design must not specify more than the correct amount of material to form the finished thread. Otherwise, the dies will become overloaded. Volume of the thread above the pitch diameter of an American Standard thread form (when using a thread depth equal to twice the addendum) very nearly equals volume of material displaced, so it is apparent that blank diameter approximates pitch diameter of the finished thread. This also holds true on other types of threads which have a balanced thread form—where addendum and dedendum are equal.

Variation in blank diameter results in variation in major diameter of the thread and blank-diameter tolerances must be controlled according to accuracy of thread to be produced. In general, blank diameters should be less than maximum pitch diameter of thread, and blank-diameter tolerances should be as small as practical for economical manufacture.

Uniformity Important: Blank diameters are prepared in a number of ways. For common fasteners, Fig. 9, such as bolts, cap screws, and machine screws, blanks are cold forged in heading machines, where close blank tolerances can be maintained. Many parts are prepared for rolling on screw machines by shaving. For very accurate threads with high hardness, blanks are usually centerless ground.

Heat treatment should be carefully controlled to give minimum variation in hardness from one blank to the next. Hardness should be kept as close as practical to minimum allowable limit to obtain maximum die life. Heat treatment should be homogeneous within the blank, permitting no

Table 3—Blank-Diameter Tolerances, Straight Threads

Thread Tolerances: Major Diam (in.)	Thread Tolerances: Pitch Diam (in.)	Thread Diameter (in.): to ½	½ to 1	1 to 1½	1½ to 2	2 to 2½	2½ to 5
0.0020	0.0010	0.0003	0.0003	0.0002	.....	.....	.....
0.0024	0.0012	0.0004	0.0003	0.0003	.....	.....	.....
0.0028	0.0014	0.0005	0.0004	0.0003	.....	.....	.....
0.0032	0.0016	0.0005	0.0005	0.0004	.....	.....	.....
0.0036	0.0018	0.0006	0.0006	0.0005	.....	.....	.....
0.0040	0.0020	0.0007	0.0007	0.0006	0.0005	.....	.....
0.0050	0.0025	0.0008	0.0008	0.0008	0.0005	.....	.....
0.0060	0.0030	0.0010	0.0010	0.0010	0.0008	0.0008	.....
0.0070	0.0035	0.0013	0.0013	0.0010	0.0010	0.0008	.....
0.0080	0.0040	0.0013	0.0013	0.0013	0.0013	0.0010	0.0010
0.0090	0.0045	0.0015	0.0015	0.0015	0.0015	0.0013	0.0010
0.0100	0.0050	0.0018	0.0018	0.0018	0.0018	0.0015	0.0015
0.0120	0.0060	0.0020	0.0020	0.0020	0.0020	0.0026	0.0015
0.0140	0.0070	0.0025	0.0025	0.0025	0.0025	0.0020	0.0020
0.0160	0.0080	.....	0.0030	0.0030	0.0030	0.0025	0.0025
0.0180	0.0090	.....	0.0030	0.0030	0.0030	0.0030	0.0030
0.0200	0.0100	.....	0.0035	0.0035	0.0035	0.0035	0.0035
0.0220	0.0110	.....	.....	0.0040	0.0040	0.0040	0.0040
0.0240	0.0120	.....	.....	0.0040	0.0040	0.0040	0.0040
0.0280	0.0140	.....	.....	.....	0.0045	0.0045	0.0045
0.0320	0.0160	.....	.....	.....	0.0050	0.0050	0.0050

Values given above are added to the minimum blank diameter obtained from use of Table 2. When major-diameter tolerance is less than twice the pitch-diameter tolerance, always use blank-diameter tolerance opposite to nearest major-diameter tolerance given above. Otherwise, refer to pitch-diameter tolerance only.

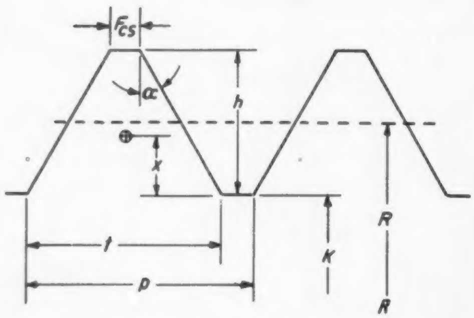
hard spots. No matter how blanks are prepared, they should be kept as uniform as possible to assure uniform accuracy in finished threads and optimum die life.

Blank Design: Recommended designs for various kinds of blanks are shown in Fig. 10. By counterboring the entrance of internal threads, Fig. 11, it is possible to eliminate necking operations on the blank, next to the shoulder. This permits greater strength in external threaded members and also permits use of a straight blank.

BEVEL ON BLANK: Ends of blanks should be beveled to prevent excessive chipping of threads on dies or rolls. Angle and depth of bevel is important. A bevel of 30 deg from axis of the blank, which gives 60 deg included angle, is preferred for general conditions. Diameter at small end of the bevel should be less than minor diameter of thread, Fig. 10. In rolling, end threads bend outward, so bevel on finished thread approximates 45 deg, Fig. 12. Bevels in excess of 30 deg, such as 45 and 60 deg with the axis, are detrimental and should be avoided where possible. Angles of 25, 20, and sometimes 15 deg are preferred for harder blanks. Length of bevel is measured on the blank diameter. Lengths of bevels for angles of 45, 30, 25, 20, and 15 deg are shown on Fig. 13.

Diameter Tolerances: Blank-diameter limits are affected by kind and hardness of materials, and surface finish of the blanks. Major and pitch-diameter tolerances, however, have the greatest influence on blank tolerances. Major and pitch-diameter tolerances determine how wide a tolerance can be used for blank diameters and still roll threads within specifications. Physical properties such as material rolled, hardness, and finish de-

Table 4—Determining Rolling Diameter for Straight Threads



All computations should be carried to six places.

$$R = \sqrt{1.273246\ (V_1 + V_2)}$$

$$V_1 = 0.785398K^2$$

$$V_2 = 0.5hn\ (t + F_{cs})\sqrt{[3.141592(K + 2x)]^2 + p^2}$$

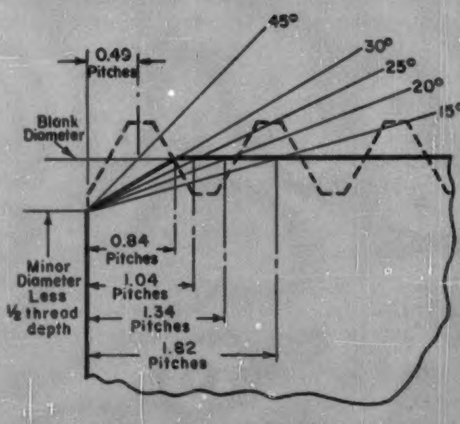


Fig. 13—Length of bevels on blank diameter for American Standard threads

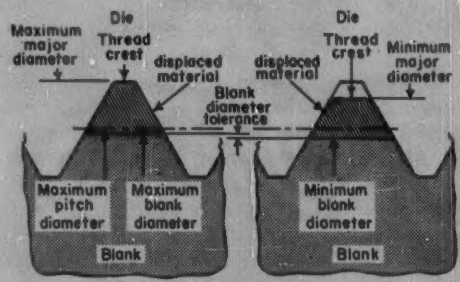


Fig. 14—Oversize blanks produce oversize threads; undersize and incomplete threads result from undersize blanks

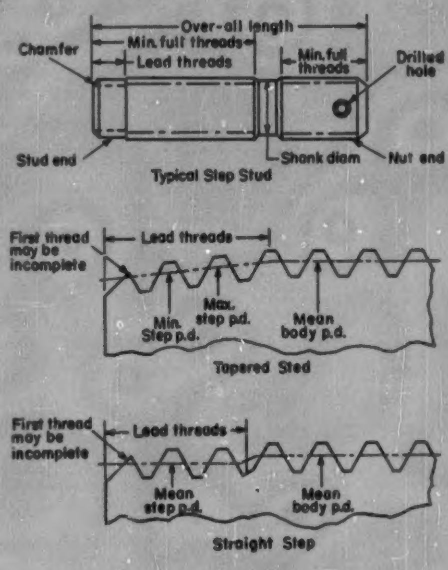


Fig. 15—Step stud, showing form of tapered and straight step threads

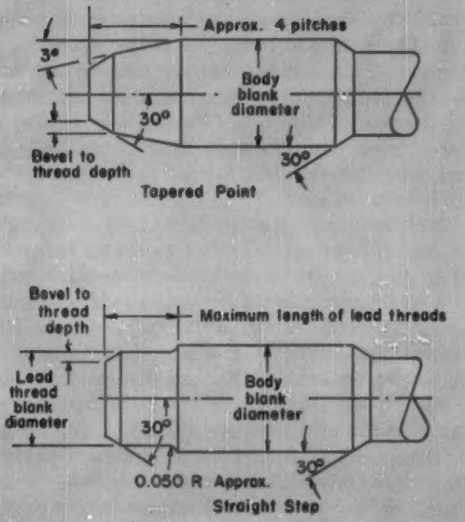


Fig. 16—Design of blanks for rolling step threads

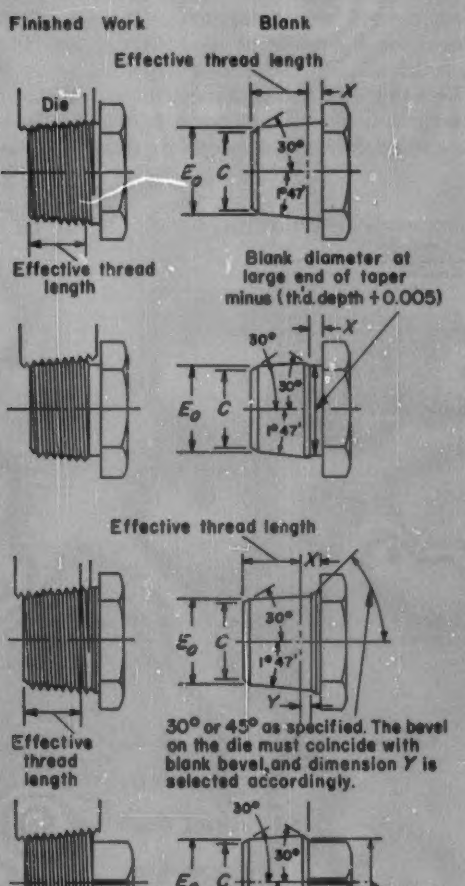


Fig. 17—Blank design for taper pipe threads. Values of dimensions X and Y are given in Table 6

termine whether blank-diameter limits will be closer to minimum or maximum pitch diameter.

Unified and American Standard screw threads allow a major-diameter tolerance of approximately twice the pitch-diameter tolerance. If pitch-diameter tolerance is one-half, or less, of major-diameter tolerance, blank-diameter tolerance is controlled by pitch-diameter tolerance. Conversely, if major-diameter tolerance is less than twice pitch-diameter tolerance, major-diameter tolerance exerts controlling influence. For a small change in blank diameter, displaced material in crest of American Standard screw thread varies by as much as four times.

Generally speaking, blank-diameter limits for softer materials and unheat-treated steels start near minimum-pitch diameter. Hard materials and heat-treated blanks usually require limits set nearer maximum pitch diameter. Smooth blanks, produced by grinding, shaving, or by forming dies, allow blank-diameter limits lower than blanks that have rough surfaces such as produced by turning. This is because rougher surfaces cause measurements to be made over tops of turned ridges and surface roughness so that measured diameter is not an accurate measure of volume.

If oversize blanks are used, oversize threads will invariably result. If undersized blanks are used, and dies are adjusted to produce a full thread, undersize major and pitch diameters will result. If the same undersized blanks are used and dies are readjusted to produce proper pitch diameter, crest of the thread will be undersize, Fig. 14. Proper blank-diameter range, therefore, must permit both smallest and largest blanks to produce finished threads to satisfy required pitch-diameter and major-diameter limits. Minor diameter is controlled by thread form and setting of the dies.

Blank Diameters: Tables 2 and 3 are for determining blank diameters for in-feed rolling of solid blanks for Unified and American Standard screw threads of not less than one diameter long up to 1 in. diam, and not less than 1 in. length for diameters over 1 in. Figures are based on balanced thread forms, where thread depth is equal to twice the addendum, and blanks have a smooth surface.

STRAIGHT THREADS: Suggested minimum blank diameters for various materials may be obtained by adding a percentage of pitch-diameter tolerance to minimum pitch diameter of the work. Maximum blank diameter may be obtained by adding minimum blank diameter to blank-diameter tolerance selected from Table 3.

Approximate blank-diameter tolerance may be obtained according to nearest major and pitch-diameter tolerances for thread diameters shown in the table. Major-diameter tolerances shown are twice pitch-diameter tolerances listed opposite. This is in line with Unified and American Standard Class 1A and 2A threads. Where major-diameter

tolerance is less than twice pitch-diameter tolerance, always use blank-diameter tolerance opposite the major-diameter tolerance.

ROUGH SURFACE: Blank diameters should be increased by larger percentages than those shown in Table 2 where surface of the blank is not smooth or contains turn-feeding marks.

SHORT THREAD LENGTHS: On shorter thread lengths, blank diameters are usually increased by larger percentages than those given to compensate for endwise stretching of blanks during rolling. A reduction in thread length or increase in the pitch results in a greater amount of endwise stretching and an increase in the blank diameter becomes more important.

ROLLING DIAMETERS: Blank diameters for other types of threads with unbalanced thread forms may be approximated by computing roller diameter of a blank for such threads. Rolling diameter is equal to diameter of a plain cylinder having same volume of material as that contained in threaded portion of a part. Formula for rolling diameter of straight threads is given in Table 4.

THIN-WALL BLANKS: Hollow cylinders with thin-walls are usually supported by arbors during rolling. Arbors should be correct size; undersize arbors will allow the hole in the cylinder to close in and thread diameter to go undersize, and tight-fitting arbors and high die pressures will sometimes stretch walls of cylinders, making both hole and thread oversize. Endwise stretching also occurs where there is a very thin wall between thread root and hole. Because of variables involved in rolling threads and forms on hollow cylinders with thin walls, blank diameters are usually determined by experimentation, but general minimum walls are given in Table 5. When rolling hollow work made from bar stock in screw machines, it is customary to roll the thread prior to machining the hole in the part.

STEP THREADS: Step studs, Fig. 15, have threads on one end known as stud threads, and on the other end, nut threads. Threads on stud end are held to closer tolerances because of a predetermined interference fit in the tapped hole. Stud threads are made in oversize diameters of prescribed increments. To start the oversize thread in the tapped hole, one to three "lead threads" at end of the stud thread are made to a smaller pitch diameter, corresponding to the pitch diameter of the tapped hole. These threads are referred to as step threads, and may be either tapered or straight, Fig. 16. Tapered lead threads are preferred by most users. Blanks with tapered points are used with tapered and straight lead threads, although the tapered-point blank is preferred for tapered-lead threads.

BLANKS FOR TAPER PIPE THREADS: Blank diameter for taper pipe thread is usually the same as the pitch diameter at small end of the taper,

Table 5—Preferred Minimum Wall Thickness

(Based on 1010 soft steel)

Threads per Inch	Blank Diameter (in.)					
	to ½	½ to 1	1 to 2	2 to 3	3 to 4	4 to 5
32	0.040	0.050	0.070	0.095	0.110	0.130
24	0.055	0.070	0.095	0.120	0.150	0.175
20	0.065	0.080	0.115	0.145	0.180	0.210
18	0.070	0.090	0.130	0.160	0.195	0.230
16	0.080	0.100	0.140	0.180	0.220	0.265
14	0.095	0.115	0.165	0.210	0.250	0.300
12	0.110	0.135	0.190	0.240	0.300	0.350
10	....	160	0.230	0.290	0.360	0.420
8	....	....	0.285	0.360	0.450	0.530

Values are for thread lengths of one diameter or less.

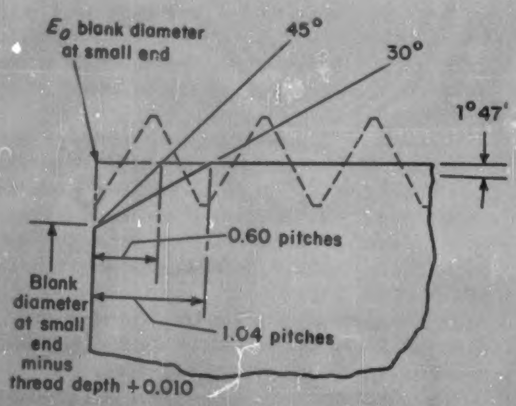


Fig. 18—Length of bevels on blank diameter for tapered pipe threads

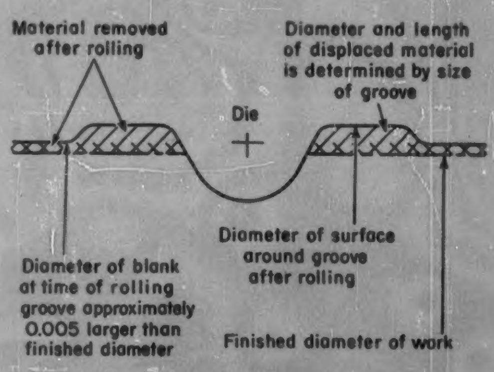


Fig. 19—Displacement of metal after oil-groove rolling operation

and has the same angle of taper as the pitch diameter, Fig. 17. Pitch diameter at small end of taper is measured at end of pipe or fitting before blank is beveled, Fig. 18. On ANPT threads, however, pitch diameter at small end is measured at point of first thread scratch, and not at end of fitting, when depths of bevel on blank are specified in excess of those shown in Table 6.

Base of a bevel next to a shoulder should not be less than *Y* distance, Fig. 17, from effective thread length to provide clearance between bevel on die and bevel on blank. The *Y* distance varies with angle of bevel on die, Table 6.

BLANKS FOR GROOVES: When rolling annular or helical grooves, such as oil grooves, provision must be made in supplementary operations for removing material displaced from outside of blank. Groove-rolling dies are designed to flatten crests of displaced material, Fig. 19, permitting excess material to be removed by centerless grinding or other means. When grooves are rolled on screw machines, excess material may be removed by either turning or shaving. Blank on which the groove is rolled should be slightly larger than finished work diameter to permit displaced material to be easily removed and also provide for a final sizing of finished work diameter.

BLANKS FOR BURNISHING: Rolling of burnished surfaces smooths out any irregularities on surface of blank. Since rolling cannot remove material and compresses it very little, it is necessary that blanks for burnishing be held to a few ten thousandths of an inch larger than finished, burnished diameter.

Design Recommendations

Whenever a material is penetrated by a thread-rolling die, a volume of material is permanently deformed. A die having a relatively sharp crest penetrates a blank easier. Particles of material pressed down by a narrow crest flow easily away from that edge and along surfaces of the flanks of the thread form, Fig. 20. Particles a short distance away from the thread surface of the die have little or no distortion.

A blunt crest on die threads, forming a wide-root flat on the blank, takes considerably more pressure to penetrate the work, since particles of material pressed down by the center of the wide flat have a greater distance to move to flow around the edges, Fig. 21. This need for greater movement also applies to particles displaced by other portions of the flat surface, with the result that blank material is deformed over a deeper and wider area.

Therefore, when rolling threads or other forms with wide-root flats, it is desirable either to round

Table 6—Blanks for Taper Pipe Threads

Thread Size	Diameter at Small End of Bevel on Blank (in.)	Pitch and Blank Diameter at Small End of Blank (excluding bevel) (in.)	Bevel on Die Rolls — 30 Deg — X† Minimum (in.)	30 Deg — Y† Minimum (in.)	45 Deg — X† Minimum (in.)	45 Deg — Y† Minimum (in.)
1/16–27	0.233	0.2712	0.0870	0.0613	0.0653	0.0505
1/8–27	0.322	0.3635	0.0870	0.0613	0.0653	0.0505
1/4–18	0.424	0.4774	0.1300	0.0915	0.0975	0.0753
3/8–18	0.560	0.6120	0.1300	0.0915	0.0975	0.0753
1/2–14	0.692	0.7584	0.1671	0.1177	0.1253	0.0967
3/4–14	0.902	0.9677	0.1671	0.1177	0.1253	0.0967
1–11 1/2	1.136	1.2136	0.2037	0.1434	0.1528	0.1180
1 1/4–11 1/2	1.480	1.5571	0.2037	0.1434	0.1528	0.1180
1 1/2–11 1/2	1.718	1.7961	0.2037	0.1434	0.1528	0.1180
2–11 1/2	2.189	2.2690	0.2037	0.1434	0.1528	0.1180
2 1/2–8	2.610	2.7195	0.2925	0.2059	0.2193	0.1693
3–8	3.231	3.3406	0.2925	0.2059	0.2193	0.1693
3 1/2–8*	3.728	3.8375	0.2925	0.2059	0.2193	0.1693
4–8*	4.224	4.3344	0.2925	0.2059	0.2193	0.1693

*NPTF not included.
†For identification of *X* and *Y* dimensions, refer to Fig. 17.

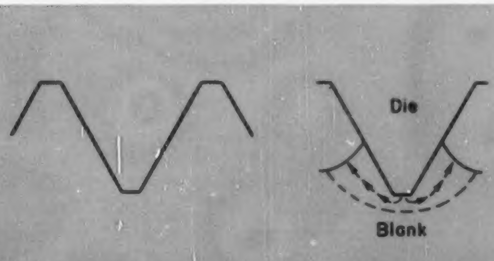


Fig. 20 — Narrow-crest dies penetrate material easily and provide excellent material flow

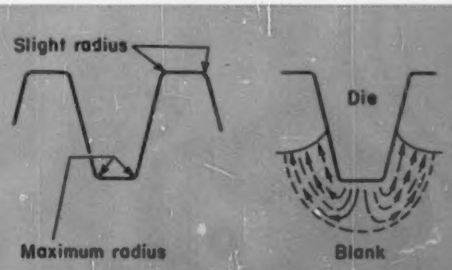


Fig. 21—Wide-crest dies require additional power for penetration, and material flow is hampered by distance that metal must move

edges of the root flat with a radii as generous as possible, or to design the thread with a full-radius root. These rounded surfaces on crests of threads on the die streamline flow of material and provide an easier entering action of dies into the blank, Fig. 22.

American Standard and similar thread forms with narrow-root flats roll easily. Threads for lag screws, woodscrews and tapping screws have wide-root flats and are usually rolled with flat dies that are specially designed to start penetration with a narrow flat, and then gradually enlarge width of flat to size.

Worm and Acme Threads: The flank of thread form produced on the worm has a slight curvature and varies from a straight line in normal and axial planes. Departure of this curvature from a straight line is known as profile deviation. Pressure angle must be great enough to prevent thread-forming tools from causing excessive deviation in thread profile. Minimum pressure angle which will satisfy this requirement increases with an increase in lead angle. Normal pressure angle of 20 deg is standard for fine-pitch gearing, and is recommended for lead angles less than 30 deg. Pressure angle of 25 deg is suggested for lead angles from 30 deg to 45 deg, although 25 deg may be used for the entire range of lead angles. Use of 14½-deg normal pressure angle is discouraged in the American Gear Manufacturers' Standard, but may be used for lead angles up to 17 deg.

A thread form with full radius at root, or a root flat with rounded corners, is necessary when rolling 29-deg worm or Acme threads. Sometimes, depth of thread is increased to permit rounding of the root flat. When designing worms for thread rolling, major diameter of worm thread should be at least six times full depth of thread, and preferably greater.

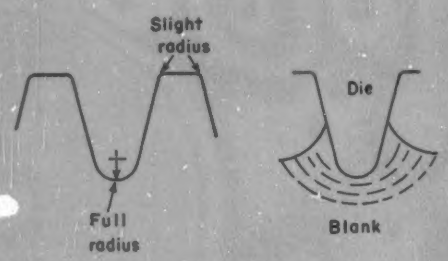


Fig. 22—Rounded die crests permit smooth material flow and have easy entry action

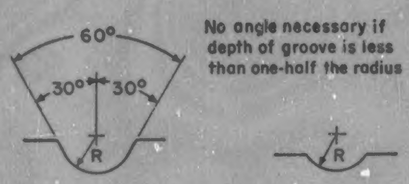


Fig. 23—Radius-bottomed oil grooves should have tangential walls if depth is over one-half the radius

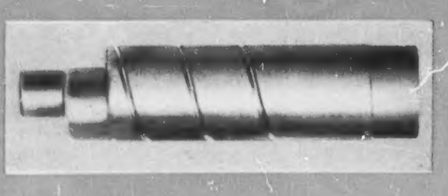


Fig. 24—Helical oil grooves should have at least 1¼ turns to provide sufficient rolling contact for the dies

Oil Grooves: Radius-formed grooves with a depth exceeding one-half the radius should be designed with angular sidewalls tangent to the radius, Fig. 23. No angles on the side of grooves are necessary if depth of grooves is less than one-half the radius. Rolled helical grooves should have at least 1¼ turns of helix to provide satisfactory rolling contact of the dies, Fig. 24.

Cross Holes: Drilling and countersinking cross-holes in the blank before rolling is not preferred practice. Rolling over holes tends to produce out-of-roundness of thread pitch diameter. This condition is especially pronounced when area of hole is large in comparison to surface area of thread. Rolling of thread over holes also reduces die life as threads on dies that come in contact with hole have a tendency to break due to uneven pressures. Most manufacturers drill and countersink holes after rolling, and deburr the threads by wire brush or with a split chaser.

KNURLS, SPLINES, AND SERRATIONS

The second article in this three-part group will discuss applications, design, blank specifications, and tolerances for knurls, splines, and serrations produced by rolling.

They Say . . .

"Four prerequisites are basic to implementation of a successful industrial research and development program. Only by careful attention to all four will results be commensurate with the expenditures. They include: 1. Acceptance of specific responsibilities by various company groups. 2. Selection of fruitful areas for research. 3. Assurance of adequate research facilities and personnel. 4. Advance planning and periodic checks during execution of the research and development program."
—EMIL OTT, *director of research, and* CARL PRUTTON, *executive vice president, Food Machinery and Chemical Corp.*

Sometimes overlooked, Mohr's Circle provides a rapid method for finding

STATES OF STRESS

By E. W. SUPPIGER
Professor of Mechanical Engineering
Princeton University
Princeton, N. J.

ONE of the simplest (and least known) of the many methods of solving the plane stress transformation equations is the graphical method of Mohr-Land—the so-called dyadic circle. An article on states of stress, using the analytic method, appeared recently in MACHINE DESIGN.[1] The two examples given therein are here solved by the dyadic circle method. This construction may be used for stresses,[2] strains, or moments of inertia[3] and may be extended to the strain rosette problem.

The procedure is indicated in Fig. 1. The known stresses (σ_x, σ_y, τ_{xy}) at a point are shown as solid lines, the unknown stresses (σ_{x1}, σ_{y1}, τ_{x1y1}) as dotted lines. Note that:

1. The magnitudes of stresses σ_{x1} and σ_{y1} are scaled along the ξ_1 axis; their directions are x_1 and y_1.
2. Stresses σ_{x1} and σ_{y1} are maxium for $\tau_{x1y1} = 0$ ($A_1 C = 0$).
3. Stress τ_{x1y1} has the magnitude $A_1 C$ and the direction y_1.
4. Stress τ_{x1y1} is maximum for $A_1 C$ = max. That is, $A_1 C = CD$.

Example 1. Given: $\sigma_x = 6000$ psi, $\sigma_y = 10{,}000$ psi, and $\tau_{xy} = -4000$ psi. The unknown principal stresses, from Fig. 2, are: $\sigma_{x1} = 3530$ psi at $\theta_{x1} = 31$ deg 40 min; $\sigma_{y1} = 12{,}470$ psi.

Example 2. Given: $\sigma_{x1} = 20{,}000$ psi ($\theta_{x1} = -20$ deg), $\sigma_{y1} = 4000$ psi, and $\tau_{x1y1} = 0$. The unknown maximum shearing stress, from Fig 3, is: $\tau_{x2y2} = -8000$ psi, $\theta_{x2} = 25$ deg.

REFERENCES

1. J. O. Predale—"States of Stress," MACHINE DESIGN, Vol. 29, No. 12, June 13, 1957, p. 157.
2. H. M. Westergaard—*Theory of Elasticity and Plasticity*, John Wiley and Sons, New York, 1952, p. 51.
3. E. Meissner and H. Ziegler—*Mechanik, Band* 1, 2 *Auflage*, Verlag Birkhauser, Basel, 1948, p. 178.

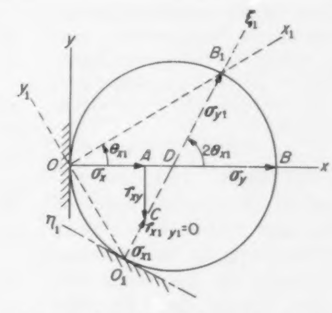


Fig. 2—Solution of Example 1.

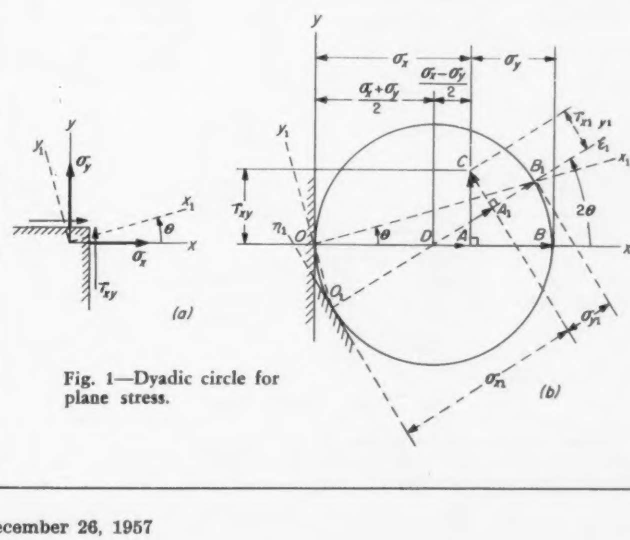


Fig. 1—Dyadic circle for plane stress.

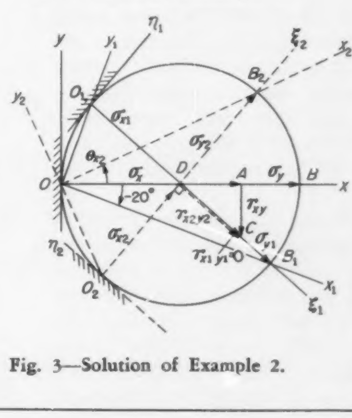


Fig. 3—Solution of Example 2.

Controlling AC-Motor Speed

using a wound-rotor frequency changer

By **HARLAN S. NEUVILLE**
Electrical Application Dept.
Allis-Chalmers Mfg. Co.
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This basic theory of applying wound-rotor motors as frequency converters points up advantages for certain variable-speed drive applications

TWO advantages of using alternating-current equipment instead of the more common dc variable-voltage drives for variable-speed applications are:

1. Most industrial installations have a ready supply of three-phase alternating current.
2. DC variable-voltage equipment is limited to lower voltages and speeds because of commutation problems.

Speed Reduction: The most obvious method of reducing speed of a squirrel-cage motor is to reduce the frequency applied to its armature. The lower the frequency, the slower the three-phase rotating field on the motor armature and, hence, the slower the rotor speed. If, however, lower frequencies are applied with the terminal voltage remaining constant, excessive current will flow and there is the possibility that the thermal capability of the motor might be exceeded.

Reducing the voltage applied to the armature of a squirrel-cage motor is another method of reducing speed. For instance, if 90 per cent of rated voltage were applied, the motor could produce only 81 per cent of its rated torque. This would result in a droop in the speed-torque curve and the rotor would readjust at a different speed to balance the load torque against the electromagnetic torque developed by the motor. The voltage reduction method is limited to very small speed ranges because it reduces the torque capability of the squirrel-cage motor.

If, however, the voltage and frequency applied to the armature of the cage motor were lowered in the same quantities (constant volts per cycle), the characteristics of the cage motor would remain essentially the same. This generalization holds only when the stator and rotor impedances are not major current-determining factors in a motor and is valid only when the

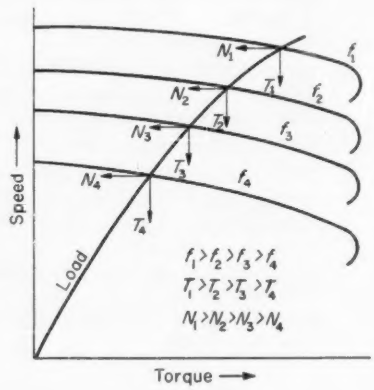

Fig. 1—A consistent set of speed-torque curves. Characteristics of the squirrel-cage motor remain the same if voltage and frequency applied to the armature are lowered in the same quantities.

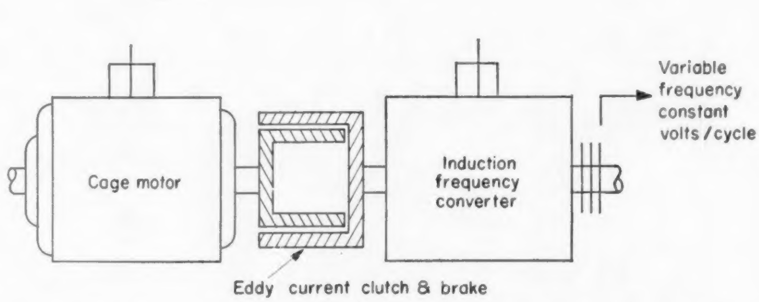

Fig. 2—Drive arrangement for producing variable frequency from rings of a wound-rotor induction motor. The eddy-current device driven by the cage motor, controls the induction frequency converter.

load is the main consideration in determining current. As shown in Fig. 1, the characteristics of a cage motor remain essentially the same while constant volts per cycle are applied. By lowering the torque characteristics of the machine, the motor assumes a new speed at which the capability of the motor matches the load.

Constant Volts-Per-Cycle Generator: One arrangement used to produce constant volts per cycle variable frequency uses the wound-rotor induction motor as a generator. The drive arrangement for producing variable frequency from the rings of a wound-rotor induction motor is shown in Fig. 2. A squirrel-cage induction motor drives the induction converter in conjunction with an eddy-current clutch and brake. Basically, the wound-rotor motor acts as a frequency converter.

If the rotor of the wound-rotor machine is braked to speeds less than the synchronous speed of the three-phase rotating field on the converter armature, a range of frequencies from 0 to 60 cycles appears across the rotor rings. The 60-cycle frequency occurs when the rotor is at a standstill.

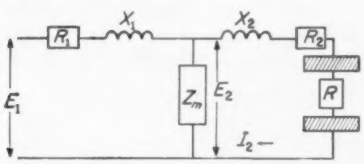

Fig. 3—Conventional per phase equivalent circuit for induction machines. Equivalent circuit determines power flow. Load resistance between rotor slip rings is represented by *R*.

If the rotor of the induction frequency converter is driven in the opposite direction from its three-phase rotating field, frequencies higher than 60 cycles are produced. When the rotor is driven in the opposite direction at synchronous speed, frequencies of 120 cycles are generated.

In applying this equipment to variable-speed applications, relationship between power out of the rings, power into the converter across the air gap, and power into or out of the converter shafts must be known. An understanding of what occurs in the driven converter can be obtained from equivalent circuit parameters when assuming that losses can be ignored.

There are three general types of loads driven by induction motors:

1. A variable-speed load in which torque remains constant.
2. A variable-speed load in which horsepower remains constant.
3. A variable-speed load in which horsepower is variable.

After the type of load is established, ratings of the converter and its supporting equipment can be readily determined. Fig. 3 illustrates conventional per phase equivalent circuit for induction machines. In this circuit the load is represented as a resistance between the rings of the converter.

Feedback Control: Two methods can be used to obtain feedback control for the ultimate load speed or converter frequency. A tachometer can be mounted on the converter shaft for measuring speed. The output of this tachometer is fed to the eddy-current control, which in turn automatically regulates excitation to the eddy-current device, thus establishing converter rotor speed. This speed in turn establishes desired frequency calibrated on the rheostat.

A more elaborate method is to drive a reluctance-type synchronous motor from the frequency output of the converter. This motor would in turn drive the tachometer, which provides the feedback signal to the eddy-current control. In this manner frequency is regulated directly. This arrangement has the advantage of regulating for frequency changes in the system connected to the converter armature. Schematics are shown in Fig. 4.

The ac drive system lends itself most readily to variable-speed constant-torque applications. It can also be used in other applications having variable torque characteristics or for loads having some characteristics between constant torque and variable torque. It is not generally recommended, however, for constant horsepower applications except where speed variations are small.

From "Variable-Speed Drives Using AC Equipment," in Allis-Chalmers Electrical Review, *Third Quarter*, 1957.

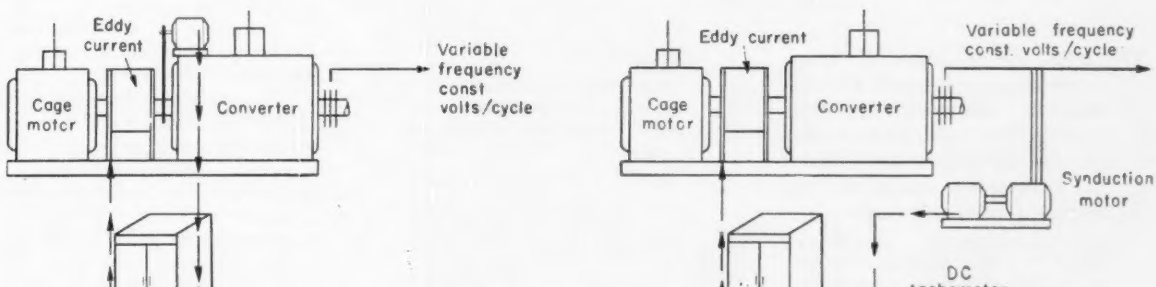

Fig. 4—Left—Feedback sequence with tachometer output fed to eddy-current control. Converter rotor speed is established by regulation of excitation to the eddy-current device. Right—Feedback sequence to regulator output frequency. Tachometer is driven by a reluctance-type synchronous motor and provides the feedback signal to the eddy-current control. With this arrangement, feedback sequence regulates converter output frequency directly.

Properties of *Lexan Plastic*

By K. B. GOLDBLUM and R. J. THOMPSON
Chemical Development Dept.
General Electric Co.
Pittsfield, Mass.

A RELATIVELY new thermoplastic material, Lexan, has exceptional impact strength, dimensional stability, high heat resistance, and good electrical characteristics. It can be pounded with a hammer, exposed to high temperatures to 284 F, immersed in water and dilute acids, and subjected to strong electrical fields—all without deteriorating effects. Lexan polycarbonate resin can be fabricated by the main methods of molding, can be solvent-welded, sealed with heat, and machined. A ¼-in. diam "nail" of Lexan plastic—its point ground in a pencil sharpener—can be driven through inch-thick plywood by repeated hammer blows. Despite the toughness of these "nails," they will not damage or dull a whirling saw blade if inadvertently left in the plywood to be cut.

Applications: The excellent properties combined in Lexan have suggested, among other things, its use for gears in clocks and business machines. These gears must be dimensionally stable, have low moisture absorption, and remain unaffected by petroleum oils. In addition, the moldability of Lexan permits close tolerances to be specified in the gear design.

Coil forms, or spools on which wire is wound, must withstand crushing, maintain their shape under winding tension, and insulate satisfactorily. Lexan, with its combination of thermal and dimensional stability, and good electrical properties, can meet these requirements.

Other applications include housings and cases for business machines and radios. Housings, molded of Lexan plastic, are thinner, lighter, and practically unbreakable—not just impact resistant.

Lexan plastic molded parts are competing with metals in a number of applications. For example, Lexan's good insulating properties and resistance to solutions of acid and salts suggest its use in storage battery and flashlight cases, and in photographic processing equipment.

Lexan enables designers to create totally new designs. Assemblies made of several small metal components can now be fabricated in one piece from Lexan. Properties of molded Lexan resin are shown in Table 1.

Table 1—Properties of Molded Lexan

Property	Value
Impact strength, notched, Izod, ft-lb/in.	12 to 16
Ultimate tensile strength, psi	8000 to 9000
Tensile modulus, psi	160,000
Elongation, per cent	60 to 100
Specific gravity	1.20
Heat distortion temp, F	280 to 290
Arc resistance, sec	10 to 11
Dielectric strength, v/mil	400
Dielectric constant,	
60 cycles	3.17
10,000,000 cycles	2.96
Volume resistivity, ohm-cm	2.1×10^{16}

From "New Plastic Gains on Metals," in General Electric Review, *November, 1957.*

Shock and Vibration Isolators

By SHELDON RUBIN
Research Engineer
Lockheed Aircraft Corp.
Burbank, Calif.

WHEN the necessity of vibration isolation between a piece of mounted equipment and the structure has been established, the following constructional and installational information should appear on isolator system drawings:

1. View or views showing interior configuration of the isolator.
   a. Location and nature of load carrying element.
   b. Location and nature of snubbing means.
   c. Location and nature of energy dissipation means.
   d. Special internal details.
2. Installation data.
   a. Location and size of mounting holes in structure, and material thickness attachment points.
   b. Detail of means of attachment to receiver, i.e., thread data etc.
   c. Outline dimensions.
   d. Tolerances on all pertinent dimensions.
   e. Special considerations such as requirements for spacers or dimpled supporting members, and clearance holes in supporting member to allow for isolator excursion.
   f. Nature of surfaces which contact supporting and supported members.
   g. Provisions for auxiliary snubbers or dampers, or alternative designs of the existing elements.
   h. Weight of isolator.
   j. Limitations on direction and magnitude of static loading.
3. Deflection information.
   a. Location of elastic center and principal elastic axes.
   b. Position under no load.
   c. Position under rated load.
   d. Distances to snubbing surfaces.
   e. Distances to positions resulting from large loads, i.e., some factor times maximum rated load.

From a paper entitled "Selection of Shock and Vibration Isolators," presented at the SAE National Aeronautic Meeting in Los Angeles, Calif., October 1957.

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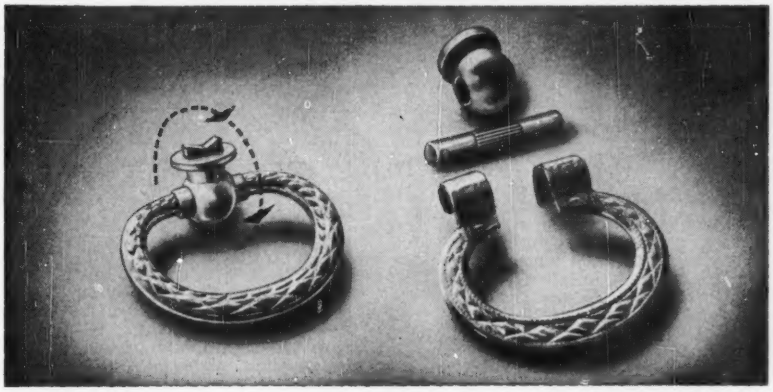

The GRC "Intercast" swivel ring on the left was cast-assembled, complete, in a single operation. The ring on the right required assembly of two screw machine parts plus a metal stamping.

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Previously, Metalcraft Corp., leading manufacturer of picture frames needed *two screw machine parts, a metal stamping plus two assembly operations* to complete their picture frame swivel rings. With Gries "Intercast" production, *a single automatic operation casts the unit completely* assembled, trimmed, *and ready for use.* This process eliminated assembly entirely, *effected economies of over 50%* and resulted in a more attractive component.

"Intercast" is only one of the exclusive Gries die casting techniques and processes that offer industry drastic reductions in production costs and new opportunities for improved design. Unique GRC machines turn out simple or intricate small parts, complete, in one high-speed automatic operation. Many manufacturers have found that Gries facilities give them a better product while reducing costs and eliminating machining and assembly operations.

Gries small zinc alloy die cast parts are made to fit size, shape and tolerance specifications *precisely.* Smallness is unlimited (maximum weight ½ ounce, maximum length 1¾ inches). All are mass-produced at low cost in quantities of 100,000 to many millions.

Send for further information on "Intercast" and other Gries small-parts production facilities, and find out how they can be applied to your particular problems.

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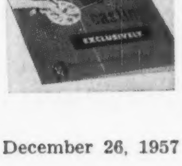
To learn how designs can be simplified and assembly operations reduced or eliminated, write for useful reference copy of Gries' fact-filled bulletin. In addition, Gries' staff is available to manufacturers for personal consultation on design and production of GRC automatically die cast and plastic molded small parts.



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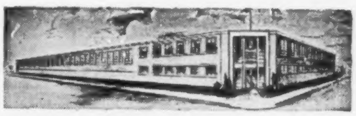
Never before available to industry as a stock item from any supplier, GRC is now stocking for prompt delivery cap nuts with up to 50% greater thread depth. Immediate shipment can be made on a complete range of hex sizes from 5/16″ to ⅝″. Die cast in zinc alloy with long, clean thread sections, the overall height of the cap nut is well proportioned between the hexagonal section and the dome of the fastener. Protective, neat and attractive, they are rustproof, corrosion-resistant, non-ferrous, without tool marks or cut-off burrs. They have a naturally bright finish and if required any standard finish can be applied. Other GRC stock fasteners include wing nuts and screws, round head thumb nuts and screws, standard cap nuts, rivets and others. Catalog and spec sheets on the new high series cap nuts and other fastenings are available on request.



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Circle 517 on Page 19

Temperature Control Valves
How to select and size temperature control valves is explained in illustrated Bulletin 655. Simple formulas and examples show how to assure proper valve sizing, essential to accurate control. 6 pages. OPW Corp., Jordan Industrial Sales Div.

Circle 518 on Page 19

Copper Foil
Data on properties and applications of Electro-Sheet copper foil are contained in Publication D-8. This electro-deposited sheet copper is produced in continuous lengths, up to 64 in. wide, and in thicknesses from 0.0007 to 0.0098 in. 8 pages. American Brass Co., Ansonia Div.

Circle 519 on Page 19

Powder Metal Parts
"How to Cut Precision Parts Costs With the Remet Powdered Metal Process" is title of illustrated bulletin. It explains what the process is, advantages and limitations, proper and faulty design factors, and specifications of available materials. 16 pages. Reese Metal Products Corp.

Circle 520 on Page 19

Rotating Joints
The functions and applications of Fawick Rotorseals for troublefree transmission of air, liquids, or gases into a rotating shaft are subject of Bulletin ML-177. Also covered are quick-release valves to provide quick evacuation of pressurized air from pneumatic system. 6 pages. Fawick Corp., Fawick Airflex Div.

Circle 521 on Page 19

Numerically Controlled Table
Details of the new 42-in. precision plain rotary table which is equipped with numerical control are presented in Circular 612. This automatic indexing table provides precise circular spacing and angular positioning. 2 pages. Pratt & Whitney Co.

Circle 522 on Page 19

Variable Transformers
Interchangeability chart provides equivalent data on type, number, and output amperage of Adjust-A-Volt, Powerstat, and Variac variable transformers to aid design engineers in selection and application. 4 pages. Standard Electrical Products Co.

Circle 523 on Page 19

Worm Gearing
Design and application of Cone-Drive double-enveloping worm gearing in all types of speed reducer drives is subject of illustrated Bulletin CD-200. It includes detailed engineering formulas and step-by-step instructions for designing this gearing into machines. 24 pages. Michigan Tool Co., Cone-Drive Gears Div.

Circle 524 on Page 19

Thermal Wells
Complete specifications on wells for thermostat applications in fluids, gases, or high pressure environments are included in Bulletin MC-158. It describes copper and stainless steel designs for immersion and surface mounting. 2 pages. Fenwal Inc.

Circle 525 on Page 19

Filtration Equipment
Fulflo and CFC filtration equipment for micronic clarification of all types of fluids, including lubricating and fuel oil, liquid chemicals, compressed air and gases, hydraulic fluids, and plating solutions, is described in illustrated catalog. Commercial Filters Corp.

Circle 526 on Page 19

Colloidal Dispersions
Colloidal graphite, molybdenum disulfide, mica, glass, copper, and custom dispersions are tabulated together with their properties and applications in Guide 2208. 4 pages. Acheson Colloids Co.

Circle 527 on Page 19

Stainless Fasteners
A complete line of stainless steel AN fasteners, including government specification aircraft bolts, slotted and Phillips machine screws, flat and round rivets, and washers which are carried in stock are listed in illustrated catalog. 12 pages. Allmetal Screw Products Co.

Circle 528 on Page 19

Teflon Hose Assembly
Aircraft catalog supplement describes and specifies the 110 Teflon hose assembly. Hose has Teflon innercore and stainless steel wire braid. Equipped with the new fittings, it is suitable for 1500 psi fluid systems operating between −100 and 500° F. 4 pages. Titeflex, Inc.

Circle 529 on Page 19

Grinding & Boring Spindles
Many practical applications are shown for Ex-Cell-O precision grinding and boring spindles in Bulletin 25477. Described are standard spindles for use as original equipment by machinery builders, or as replacements. 8 pages. Ex-Cell-O Corp.

Circle 530 on Page 19

End Face Seals
Pre-engineered to meet a wide range of sealing requirements, C/R standard face end seals are available

in long and short types. Specifications include ¾ to 4-in. shaft sizes, pressures to 500 psi, temperatures to 500° F and peripheral speeds to 15,000 rpm. Complete performance and design data are included in Bulletin EF-100. 6 pages. Chicago Rawhide Mfg. Co.

Circle 531 on Page 19

Ultra-Strength Steels

Ultra-strength structural steels with yield strengths over 200,000 psi are subject of booklet. It contains technical data and a number of tables concerning composition and properties. It also outlines various end uses of these steels. 16 pages. Climax Molybdenum Co.

Circle 532 on Page 19

Flexible Couplings

Bulletin 99 descriptively covers Type SS and ST semifloating shaft couplings for radial loads. These flexible couplings are used where units are spaced apart and one bearing only is provided for one of the units. Parallel misalignment is eliminated. 4 pages. Thomas Flexible Coupling Co.

Circle 533 on Page 19

Hydraulic Motors

Four new sizes are included in the line of 36 constant displacement piston type hydraulic motors covered in Bulletin A-5205-A. Power range is now 3.8 to 117.4 hp in intermittent service at 3000 psi. Upper ambient limit is now 275° F. 4 pages. Vickers Inc.

Circle 534 on Page 19

Electronic Equipment

Meter calibrators, voltage regulators, digital readout meters, and dc power supplies are among electronic equipment for lab or production use covered in catalog. Complete information and operating data for all models are given. 8 pages. Davenport Mfg. Co.

Circle 535 on Page 19

Carbon & Low Alloy Steels

Included in folder showing facilities of this company is a two-page spread chart which tabulates analysis, physical properties, and specifications on carbon, low alloy-high tensile, die, stainless, and heat resistant stainless steels. 6 pages. Induction Steel Castings Co.

Circle 536 on Page 19

Flexible Shaft Couplings

The Diamond taper-bushed flexible coupling is included in descriptive Catalog 7 which charts horsepower ratings, dimensions, maximum rpm, and other engineering data necessary for selection. Finished bore type is also covered. Coupling member is a double strand roller chain. 8 pages. Diamond Chain Co.

Circle 537 on Page 19

Heat Exchangers

Standard dimensions for single and two-pass CRB copper shell removable bundle heat exchangers are charted along with practical flow ranges and heat transfer rates in Bulletin HT-4. Working pressure and temperature are 75 psi and 300° F, respectively. 6 pages. Yates-American Machine Co.

Circle 538 on Page 19

Slide Assemblies

Light and heavy duty slide assemblies with working surfaces from 2 x 3 to 8 x 24 in. and strokes from ¾ to 8 in. are described in Bulletin 125. Units are offered with return spring, lead screws and micrometer stops, as well as with cylinder power. 8 pages. Russell T. Gilman, Inc.

Circle 539 on Page 19

Carbon Graphite

Characteristics, grades, and suggested uses for carbon graphite are featured in Catalog 58. Purebon special impregnations afford over 100 different combinations. Some withstand oxidation in air up to 1000° F or will run as dry bearings or seals at 500° F ambients. 12 pages. Pure Carbon Co.

Circle 540 on Page 19

Motorized Devices

Instrument panel vibrators, dc generators, planetary gear reducers, clutches, rate gyros, actuators, timers, and power positioners are among miniature motorized devices described by respective data sheets bound in folder. These industrial control devices meet various MIL specs. 18 pages. Globe Industries, Inc.

Circle 541 on Page 19

Special Steels

Process equipment and facilities for production of drawn steel shapes are shown in brochure. These facilities handle cold drawn, cold rolled and centerless ground carbon, alloy and stainless steel, and other nonferrous metals. 8 pages. Eaton Mfg. Co., Reliance Div.

Circle 542 on Page 19

Externally Wrenched Screw

The Ferry Cap Countr-Bor screw fits flush in standard counterbored holes and is wrenched externally with standard wrenches. Descriptive folder provides diagrams, size ranges, and specifications. 4 pages. Ferry Cap & Set Screw Co.

Circle 543 on Page 19

Digital Recorders

Tape punch, print-punch, scanning printer-perforator combinations, time data printer, printing timer, printing input keyboard, and standard data printer machines are among the digital recording equipment described in illustrated Brochure SA-81. 6 pages. Clary Corp.

Circle 544 on Page 19

Laminated Plastics

Pocket-size Bluebook stock list of industrial laminated plastics provides data on all copper clad grades, as well as on engraving stock, standard sheet stock, 36-in. rod stock with ¼ to 1 in. diameters, and CN end grain material. Formica Corp.

Circle 545 on Page 19

Electron Tubes

The 1958 edition of the "RCA Reference Book" contains latest information for design engineers on electron tubes, test equipment, batteries, transistors, and semiconductor diodes. Quick selection guide aids in choosing proper power, cathode ray, photo, and special tubes and semiconductor devices. Receiving tube characteristics are tabulated. 216 pages. Radio Corp. of America, RCA Electron Tube Div.

Circle 546 on Page 19

Hairsprings

Revised edition of "Manross Hairsprings" is a practical guide to the design and specification of hairsprings for instruments, gear trains, clocks, and other fine mechanisms. Material recommendations for specific operating conditions are given. 8 pages. Associated Spring Corp., F. N. Manross & Sons Div.

Circle 547 on Page 19

Relays, Thermostats, Switches

"Check List of Reliable Controls" contains capsule data on Diamond H relays, thermostats, rotary switches, range switches, motor controls, and snap-ins for air conditioning, aircraft, appliances, automation, electronics, guided missiles, machine tools, and panel boards. Hart Mfg. Co.

Circle 548 on Page 19

High Vacuum Items

Bulletins 9-1 and 10-1 respectively cover high vacuum gages and high vacuum valves, baffles, and traps. Gages are made to measure pressures from 100 mm Hg to an almost nonexistent 2 x 10^{-12} mm Hg. Valves range in sizes from ¼ to 20 in. diameter. 24 and 28 pages, respectively. Consolidated Electrodynamics Corp., Rochester Div.

Circle 549 on Page 19

Pipe for Nuclear Use

Information on stainless steel and special alloy tubing and pipe for use in nuclear energy applications is provided in Bulletin T.D. 123. It lists 34 analyses available and discusses several installations of this tubing and pipe. 4 pages. Carpenter Steel Co., Alloy Tube Div.

Circle 550 on Page 19

Oscillographic Recorders

Sanborn 150 oscillographic recording systems and a full line of accessories and unit instruments are described and specified in catalog. Equipment includes 1 to 8-channel systems, plug-in preamplifiers, the Model 150-3100 Triplexer, portable systems, and analog computer readout systems. 16 pages. Sanborn Co., Industrial Div.

Circle 551 on Page 19

Welded Steel Rings

Basic phases in manufacture of welded steel rings, including bending, electronically-controlled welding, sizing, heating, and X-ray inspection are illustrated in bulletin. 8 pages. Edgewater Steel Co.

Circle 552 on Page 19

Metal-Clad Plastics

Six of most widely used metal-clad laminates for printed circuitry are described as to strengths, properties,

THIS IS GLASS

a bulletin of practical new ideas *from Corning*

The long and the short of it ... a primer on optimum heating methods

Take a white-colored object and place it near an infrared lamp with a Kelvin rating of 2500°. Some *30%* of the radiant energy will be absorbed.

Next take an ordinary sheathed wire unit at 1000°K. The same object will absorb *70%* of the measurable output.

Now take a new PYREX® industrial radiant heating panel. It looks like this.

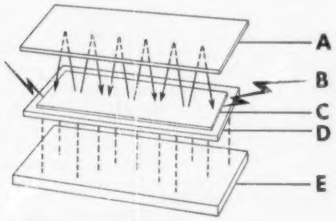
It operates at 600°K. and your white object will now absorb *90%* of the radiant energy.

Behind these differences lies the question of *wave length* emitted by each source. Infrared lamps peak at 1.2 microns; a sheathed unit like the one described hits 3. But the PYREX heater gives from 5 to 20 microns.

It's the *longer* wave lengths that make the difference. And *more* absorption means *more* effective heating per unit of energy expended.

These wave lengths offer you two distinct advantages: (1) all colors will absorb nearly the same amount of them—this means even heating regardless of color and (2) all colors will absorb these waves much more readily than they will the short wave lengths of lamps or sheath wires. With white colors, the absorption is greater with panels than lamps by a factor of nearly 4 to 1.

PYREX industrial radiant heaters have as their heart a panel of tempered *glass* that has a fused-in coating of thin conducting film. The panel is mounted in an aluminized steel frame. A self-contained unit, each heater comes with built-in aluminized steel reflector, mounting hangers, junction box and leads.



A. Reflector—aluminized steel
B. Electric current
C. Resistance element—conductive film
D. Heating element—tempered glass
E. Work—*all* materials except metallic reflectors

Because it's tempered the glass panel is *rugged;* it also is extremely corrosion resistant. Maintenance is a negligible factor since occasional dusting with a dry cloth is sufficient. If needed, heaters can be cleaned when cold by rubbing gently with a soft rag lightly dampened with alcohol.

PYREX radiant heating panels come in 8 different models, the smallest 11⅝″ square, the largest 23⅝″ square. (Note: rectangles are included in this selection.)

Watts per square inch go from 5.4 to 9.5 and the element itself (when measured in ambient air at 70°F.) runs from 550°F. to 660°F.

Heaters can be mounted horizontally, above *or* below work; vertical installations also possible and practical.

The heat you get from such units is *uniform* (because it's an *area* source) and *effective* (because of its *long* wave).

PYREX radiant heaters look like a real "hot" answer for drying, baking, curing, preheating—just about any application where you want to put the *heat* on and get the most for your investment in space and kilowatts.

Bulletin PE-60 gives the salient data on construction, installation, ventilation, wiring and controls, and maintenance. There's also a full story on where to get and how to use the Corning "Process Prover"—a "pilot" setup complete with percentage timer, pyrometer, variable table and such. PE-60 is free. Using the coupon facilitates matters.

15 gets you 75

Somebody in one of our offices has figured out that 75% of the products we now make were *not* in production 15 years ago. Which means? Glass (as engineered by Corning) is appearing in ever-increasingly useful forms.

Take a few minutes to glance through "This Is Glass" for a sprightly review of this growth. Or brief your problem and let us see if we can't come up with a *glass* answer.

Rounding out the line

Possibility: Some day the writing tip of your ball point pen may be made of glass. *Certainty:* In sizes somewhat larger than those useful for such a purpose, glass balls are available *now* and in *quantity.*

Before final grinding and polishing they look like this.

Since a number of other materials have long been available in sphere form, this news may not appear so startling.

Still a number of considerations that may interest you are involved. First—*Continuous* production of *optical* quality glass was accomplished—no mean feat. Then, Corning developed a *new*, high-speed machine for forming small diameter glass balls.

With this machine now in operation, the following specifications pertain:

Basic data on glass balls

Diameter range	.133″ min.
	.425″ max.
Diameter tolerance .	±.012″
Sphericity of ball within	.008″

What can you do with bits of glass like this? So far interest has been evidenced for using them in finger tip spray dispensers, for hand lotions and cosmetics, valves for blood transfusion and oxygen equipment, and hydrolytic controls.

Corrosion resistant, small, noncontaminating, nonmagnetic, capable of taking a fine finish—glass balls await your evaluation.

Inquiries marked for Railroad and Industrial Sales will get fast action.

Corning means research in Glass

CORNING GLASS WORKS, 52-12 Crystal Street, Corning, N. Y.

Please send me the following: Bulletin PE-60 "PYREX® Brand Industrial Radiant Heater" ☐; "This Is Glass" ☐.

Name__________ Title__________

Company__________

Street__________

City__________ Zone_____ State_____

Circle 454 on Page 19

and dimensions in folder S957. Four paper-base and two woven-glass fabric-base laminates are discussed. Sheet sizes and thicknesses are given. 6 pages. Synthane Corp.

Circle 553 on Page 19

Temperature & Pressure Controls

Self-operating regulators, water mixing equipment, pneumatic control instruments, indicating and recording instruments, and control valves are among controls described in Bulletin Rb 24. Equipment is designed for industrial process control, ventilating, and hot water service. 12 pages. Powers Regulator Co.

Circle 554 on Page 19

Digital Signal Converters

Model DD-2 drum quantizer and associated amplifier directly converts electric input signals from a transducer to teletype and other forms of output codes. Catalog 17 describes these digitizing drum units and auxiliary components. 4 pages. Union Thermoelectric Corp.

Circle 555 on Page 19

Master Switches

Features, modifications, and operating advantages of G-E surface-mounted and desk-mounted heavy-duty master switches are discussed in Bulletin GEA-6706. Former are used in steel mills, electric shovels, and cranes, whereas latter are used on control consoles. 8 pages. General Electric Co.

Circle 556 on Page 19

Centrifugal Fans

Catalog 1121 describing Airfoil centrifugal fans places emphasis on efficiency of airfoil blading for all-purpose applications. Series 8000 fans cover every requirement up to 700,000 cfm and up to 16¾ in. total pressure. Selection charts aid specifying. 12 pages. Westinghouse Electric Corp., Sturtevant Div.

Circle 557 on Page 19

Plug & Receptacle Connector

The Hyfen solderless, multilead plug-and-receptacle connector is subject of technical Bulletin HYF-7. Wires tipped with crimped-on pins or sockets are snap-locked in the plug and receptacle. Versatility in wiring of electronic harnesses is featured. 4 pages. Burndy Corp., Omaton Div.

Circle 558 on Page 19

V-Belt Drives

Comprehensive Bulletin A661 on V-belt drives is packed with information on selection and operation of Dodge V-belt drives. Sections cover standard, variable speed and special drives; Taper-Lock sheaves; Sealed-Life V-belts; and Taper-Lock bushings and hubs. Exploded views illustrate technical sections which contain tables of pre-engineered drives for easy selection. 108 pages. Dodge Mfg. Corp.

Circle 559 on Page 19

Collector Rings

Cylindrical and annular style collector rings are illustrated in Bulletin 83. Folder shows how to prepare data for estimating and provides in itself blank forms for listing data. 6 pages. B. A. Wesche Electric Co.

Circle 560 on Page 19

Shock-Free Line Valves

Model 500 Quantrol valves which utilize the principle of balanced and unbalanced line pressure, are designed to handle oil, gas, or water at pressures up to 150 psi. Construction and operating details are provided in Bulletin 650. 4 pages. Ralph N. Brodie Co.

Circle 561 on Page 19

Elapsed Time Indicators

Subminiature, hermetically sealed elapsed time indicators in the 25200 Series are described on Data Sheet ET 602. Designed for operation on 115 v, 400 cps power supplies, they are offered in dial and digital types. Specifications are given in detail. 2 pages. A. W. Haydon Co.

Circle 562 on Page 19

Steel Tubing

Revised catalog CS-58 describes carbon and alloy seamless steel tubing in mechanical, aircraft mechanical, airframe quality, and pressure grades. Fabricating and forging of tubing into special shapes and parts is also covered. 8 pages. Copperweld Steel Co., Ohio Seamless Tube Div.

Circle 563 on Page 19

Chain Oilers

Mounted at any convenient location, Trico chain oilers automatically apply a film of oil to chains, gears, slides, or irregular surfaces. Applicators withstand up to 275° F. Bulletin 39 describes and specifies these oilers. 4 pages. Trico Fuse Mfg. Co.

Circle 564 on Page 19

Machinery Making Facilities

Company facilities for the design and manufacture of special industrial machinery are well illustrated in Bulletin 157. Booklet lists company lathes, planers, drill presses, boring and milling machine, and pictures its pattern shop, erecting floor, and engineering department. 16 pages. Lake Erie Machinery Corp.

Circle 565 on Page 19

Stainless Fasteners

Condensed stock list illustrates 37 different types of standard stainless steel fasteners with appropriate dimensional information. Screws, nuts, bolts, washers, rivets, and government specification AN fasteners are included. 8 pages. Allmetal Screw Products Co.

Circle 566 on Page 19

Pilot Check Valves

Manual release for emergency conditions is a feature of single and double pilot check valves described in two catalog sheets. Single valve is available in ¼, ⅜, and ½-in. sizes, while the double model is offered in ⅜ and ½-in. sizes. Fluid Controls, Inc.

Circle 567 on Page 19

Gaskets

Features and design factors of Guardian spiral-wound metal gaskets are detailed in illustrated Bulletin AD-104. Types for use against steam, oils, gases, and liquids, including most chemicals in high pressure-high temperature service, are available. 12 pages. Garlock Packing Co.

Circle 568 on Page 19

Protective Coating

Mono-Seal, a tough plastic type protective coating for use on such equipment as trucks, structures, boats, floors, and tanks is subject of illustrated technical Bulletin MS-57. Its properties and characteristics are given. Available colors are shown. 12 pages. Mono-Seal Products.

Circle 569 on Page 19

Rotary Seal

"Solving the Problems of Seals for Rotating Shafts" is title of spiral-bound brochure which explains the principles of mechanical shaft sealing. Component parts of such seals are described and illustrated. Application data are included. 12 pages. Muskegon Piston Ring Co., Rotary Seal Div.

Circle 570 on Page 19

Sealed Gear Pump

Sealed gear pump for mounting in any machine which requires fluid circulation for lubrication or other purposes is described and illustrated in Catalog TR-57D. Unidirectional and reversible models are detailed. 2 pages. Bijur Lubricating Corp.

Circle 571 on Page 19

Tungsten Carbide Surfacing

Uses of Kenplate tungsten carbide surfacing in protecting metal parts against abrasion and wear are described in illustrated Bulletin B-106. Application methods are covered. Kenplate consists of small hexagonal carbide buttons on a backing material for bonding to metal. 4 pages. Kennametal Inc.

Circle 572 on Page 19

Power Relay

Characteristics, features, and technical data on Type 33B general purpose power relay are found in illustrated folder. Dimensional drawings and standard stock and contact listings for ac and dc relays are included. 6 pages. Phillips Control Corp.

Circle 573 on Page 19

Resistance Thermometers

"How to Use Platinum Resistance Thermometers in Temperature Measurement, Telemetry, and Control" is an illustrated booklet covering various types of these instruments. Characteristics of specific resistance thermometers are presented. 16 pages. Trans-Sonics, Inc.

Circle 574 on Page 19

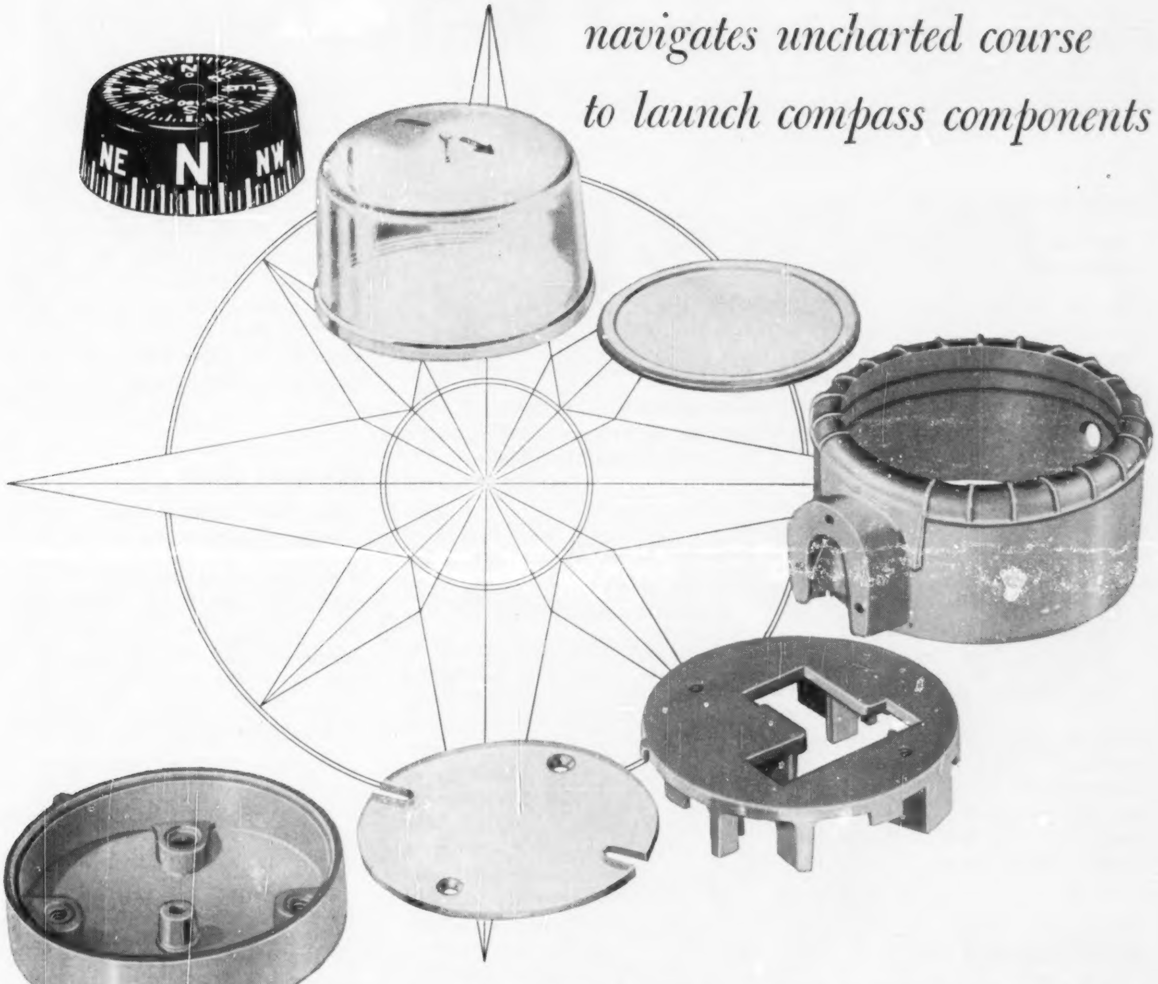
Aircraft Fasteners

Line of AL aircraft Huckbolt fasteners and ALS aircraft Huckbolt stumps is described in illustrated Catalog 8-411. Nature of two fastener types and their driving cycles are covered. Fastener specifications, installation data, and information on driving tools are among contents. 16 pages. Huck Mfg. Co.

Circle 575 on Page 19

NOSCO "CAN DO"

navigates uncharted course to launch compass components



When charting the molding and decorating of seven plastic compass parts for Taylor Instrument Companies, Nosco "Can Do" recognized the hidden danger threatened by the lettered "compass card." This card is cone-frustrum shaped and it's no simple matter to line up the peripheral lettering around the side surface with the conventional flat hot stamping on the top. The card was molded in a multiple cavity die and each cavity had to be sized perfectly so that all parts would be exactly alike . . . else the lettering would be off. To apply the peripheral lettering consistently and correctly, Nosco designed and built a synchronized, self-indexing roller stamping machine.

The other compass parts were molded in two combination molds handling three items each—cutting down both tooling and molding costs. Nosco also annealed the two thin-walled plates and provided a mirror finish on the crystal-clear acrylic dome. The result? A compass that's true.

Why not try Nosco "Can Do" on your next plastic part? Let one of our sales-engineers advise your buyers and designers how Nosco "Can Do" can produce your needs in practical plastics. Just write.

For other case histories—and for a glimpse of the Nosco plant and facilities, send for the free 12-page brochure, "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

NOSCO plastics, inc. • erie 2, pa. *World's largest injection molding plant*

Circle 455 on Page 19

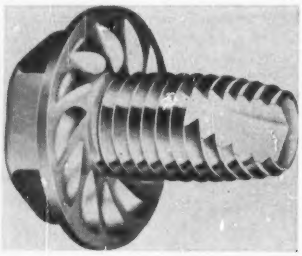
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Thread-Cutting Screw

has high stripping torque

Nibscrew is for applications that have little screw-thread engagement. Nibs or protrusions under the head act as the brake. Head takes up the tightening torque, permitting a broad range of driver



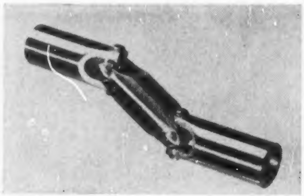
settings, and reduced rework and rejections. Sizes available are No. 4 through $\frac{1}{4}$ in., with pan, truss, and hexagon washer heads. **Shakeproof,** Div., Illinois Tool Works, St. Charles Road, Elgin, Ill.

Circle 576 on Page 19

Double Universal Joint

miniature unit has zero backlash

Mini-Joint double universal joint effectively cancels nonlinearity of phase relationship which exists in single joints. Preloaded bearing surfaces, consisting of burnished sockets and precision balls with sealed-in lubrication, give continuous contact with zero backlash. Joints are bored to shaft sizes of 3/32, $\frac{1}{8}$, 3/16, and $\frac{1}{4}$ in. Maximum operating angle is 60 deg, and maximum torque, depending on body size, is 4 to 64 oz-in. The stainless-steel joints are suited for applications such as the coupling of synchros, resolvers, subfractional-horsepower motors, indicator repeaters, potentiometers, phase shifters, and similar control and



instrumentation systems. **Falcon Machine & Tool Co.,** 209 Concord Turnpike, Cambridge, Mass.

Circle 577 on Page 19

Hollow Bar Stock

is available in aluminum alloy 2011-T3

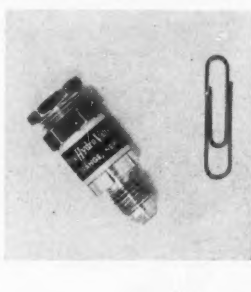
Hollow aluminum bar stock is available in round and hexagonal shapes in a variety of sizes. Alloy 2011-T3 is designed for high-speed operations, and offers excellent machined finishes at a low rate of tool wear. It is useful for threading, tapping, and screw machine work where free-cutting aluminum is desired. Reduced working temperatures permit accuracy for close tolerance work. **Harvey Aluminum Div.,** Harvey Machine Co., 19200 S. Western Ave., Torrance, Calif.

Circle 578 on Page 19

Pneumatic Relief Valve

subminiature unit is for 200 to 4000-psi pressures

This subminiature relief valve weighs less than $\frac{1}{2}$ oz and measures $\frac{5}{8}$ by $1\frac{3}{4}$ in. Design permits chatterfree action, zero leakage up



to cracking pressure, and quick, positive reseat. Unit has a capacity of 8 to 12 cfm, and operates over a pressure range of 200 to 4000 psi. Temperature range is −65 to 250 F. Valve is adaptable for low-flow hydraulic service. **Pneu-Hydro Valve Corp.,** 364 Glenwood Ave., East Orange, N. J.

Circle 579 on Page 19

Miniature Clutch

has fast response and zero backlash

Miniature electromagnetic clutch, designated Model CF, offers fast response, zero backlash, high efficiency per unit weight, and vibration resistance per MIL-E-5272A. Clutch, which is normally engaged and is energized to free, is designed

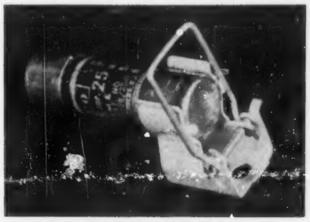
for direct-current operation. It performs efficiently on full-wave rectified alternating current without filtering. Unit is available in four sizes with minimum torque ratings of 2, 8, 16, and 32 oz-in. **Autotronics Inc.,** Route 1, Box 812, Florissant, Mo.

Circle 580 on Page 19

Locking Clips

for electrical components

Phosphor bronze locking clips are designed to hold ferrule resistors and other cylindrically shaped components securely under extreme environmental conditions of shock, vibration and heat. Available in silver, nickel, or with cadmium plating, clips meet BuShips specification RE28F121B. Stain-



less-steel locking springs eject component from clip. Clips are available in nine sizes for components from $1/4$ to $1\frac{1}{8}$ in. **Atlas E-E Corp.,** 47 Prospect St., Woburn, Mass.

Circle 581 on Page 19

Insulating Varnish

Class F material is for high-temperature use

Class F polyester-type insulating varnish cures to a tough, flexible film with good adhesive and electrical properties. It resists oil, moisture, and acid. Varnish is compatible with most materials found in electrical equipment, and is supplied in a solvent that will not cause excessive swelling of most types of silicone-rubber leads. Applications include treating of transformers, magnet coils, stators, fields, low-speed armatures, railway field coils, bare copper coils, and in other uses under elevated temperatures (155 C) where high bonding strength is not a major consideration. **General Electric Co.,** One River Rd., Schenectady 5, N. Y.

Circle 582 on Page 19

Miniature Switch

has $1/4$-in. overtravel after actuation

No. 6132 miniature switch consists of two standard hermetically sealed

Circle 456 on Page 19

miniature switches, in a dust and moistureproof case, and a plunger-type actuator. Actuator is spring-loaded, and operating force can be adjusted to meet individual requirements. Molded rubber sleeve and potting keep entire assembly dirt-free. Switch has ¼-in. overtravel after actuation. It meets military requirements for standard atmospheric environmental conditions, and meets MIL-E-5272A standard for shock and vibration. **Haydon Switch Inc.**, 536 S. Leonard St., Waterbury 20, Conn.

Circle 583 on Page 19

Pillow Blocks

have graphited cast-bronze bushings

Two new Series 240 steel-housing pillow blocks are for shaft sizes of 1-3/16 and 1-1/4 in. Units incorporate graphited cast-bronze

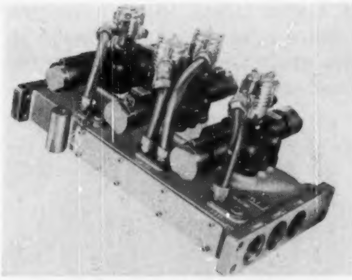
bushings. They can be mounted horizontally, vertically, or inverted. The pillow blocks are 3-3/4 in. high, 5-5/16 in. long, and have a base of 15/16 in. Bearing length is 2 in. **Randall Graphite Bearings Inc.**, Box 839, Lima, Ohio.

Circle 584 on Page 19

Hydraulic Manifold

for multiple mounting of solenoid valves

High-capacity manifold provides compact group mounting of basic ¾-in. two, three, and four-way pilot-operated control valves. The cast-aluminum manifold, available in two and three-station types, has full length inlet and exhaust ports, common to all valve stations. A conduit passage for electrical wiring, with removable cover for easy access to connections, also runs the full length of the manifold. Dirt and moistureproof flexible



conduit encloses pilot solenoid leads. Manifold is machined for both side and bottom cylinder porting. Two or more assemblies can be ganged together to provide mounting of four or more valves. **Valvair Corp.**, 454 Morgan Ave., Akron 11, Ohio.

Circle 585 on Page 19

Miniature Relay

has dual hermetic seal

Seal-Temp miniature high-temperature telephone-type relay incorporates a relay coil which is sealed separately before sealing entire relay. By hermetically sealing off coil from contact chamber, most organic contaminants are eliminated from the contacts. Temperature range is −65 to 125 C. Relay weighs about 5 oz, operates under shocks of 30 g and vibra-

tions of 5 g from 55 to 500 cps. **Potter & Brumfield Inc.**, Princeton, Ind.

Circle 586 on Page 19

Subminiature Motor

provides 10 oz-in. torque at 1 rpm

Subminiature, 115-v, 400-cycle hysteresis synchronous motor meets electrical and environmental requirements of airborne electrical components. It operates at 3000 rpm and provides 10 oz-in. torque

New Parts

at 1 rpm. Unit incorporates reversible rotation. A gear train is also available which can be incorporated with the motor. It provides a wide range of output speeds. **Advanced Products Co.,** 59 Broadway, North Haven, Conn.

Circle 587 on Page 19

O-Ring Compound

for −65 to 275 F temperature range

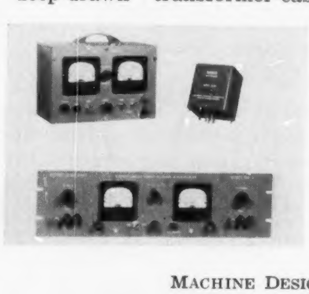
Compound 737-70 is for service in aircraft hydraulic systems with MIL-O-5606 hydraulic oil, over temperature range of −65 to 275 F. It meets requirements of specification MIL-P-25732 (ASG). All sizes on companion drawing MS28775 can be furnished from standard tooling. **Precision Rubber Products Corp.,** 3110 Oakridge Drive, Dayton 7, Ohio.

Circle 588 on Page 19

Power Supplies

are low-voltage, transistorized units

Minisource low-voltage power supplies are semivariable, with nominal voltages ranging from 6 to 50 v and full-load current ratings from 50 to 500 ma. Designed for either 60 or 400-cycle operation, units have ripple and regulation factors better than 0.5 per cent. Temperature range of operation is − 30 to 65 C. Units have passed shock and vibration tests. Shown are a unit for laboratory use (top, left), a deep-drawn transformer-cased



unit for incorporation with instrumentation (top, right), and a unit panel-mounted for use in a transistorized computer application (bottom). **Electronic Assembly Co. Inc.**, 5 Prescott St., Boston 19, Mass.

Circle 589 on Page 19

High-Pressure Valves

for hazardous locations

Explosionproof solenoid valves are rated for oil and water pressures from 0 to 250, 0 to 1500, and 0 to 3000 psi, and air pressures from 0 to 250, 0 to 1000, and 0 to 1500 psi. Designed for use in hazardous locations, they are available in four-way, three-way, shut-off and diverter flow patterns. Standard

ac voltages are 110, 220 and 440 v. Sealing ring is in constant, intimate contact with a mating slide. Metal-to-metal sealing surfaces continue to lap themselves with each operation. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

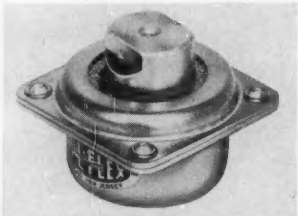
Circle 590 on Page 19

All-Metal Mounting

for airborne equipment

Model 1459 low-frequency, all-metal mounting is for airborne resolvers, computers, and radar search equipment. Natural frequency is between 5 and 9 cps for vibration protection. Mounting possesses high inherent damping characteristics for longer equipment life under severe conditions. Unit accommodates loads of 16-23 lb. It can be used in multiple units to mount airborne components requiring shock and vibra-

Circle 461 on Page 19



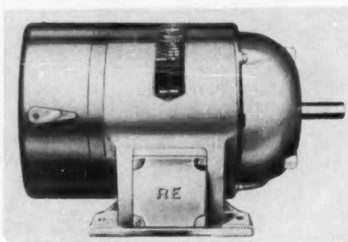
tion protection as set forth in MIL-C-172B. **Robinson Aviation Inc.**, Teterboro Air Terminal, Teterboro, N. J.

Circle 591 on Page 19

Brakemotors

are single-frame, packaged units

Brakes and motors are designed for use with each other when made into a single brakemotor unit. Wafer-type brake reduces overall dimensions. Brake magnet permits extending the shaft clear through the brake so that it can be mounted on the input or output sides of gears or fluid couplings. Drive motors are available in NEMA frame sizes 182 through 326U, either dripproof or



totally enclosed. Operating ratings of brakes are from 3 to 60 lb-ft, continuous duty, and from 3 to 75 lb-ft, intermittent duty. **Reuland Electric Co., 3001 W. Mission Rd., Alhambra, Calif.**

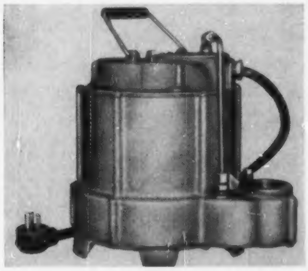
Circle 592 on Page 19

Submersible Pump

has 5000-gph capacity at 10-ft head

Improved Model 110 submersible pump combines the high torque output of a ½ hp motor with new direct-drive, nonclogging pump impeller. It uses a ceramic seal-seat mounted on impeller back to seal motor shaft from fluid being pumped. Capacity has been increased to 5000 gph at a 10-ft

head, with 30-ft shut-off head. Pump provides dependable service in sump applications in utility tunnels, elevator pits, transformer vaults, removal of factory wastes and air conditioning condensate, circulating machine tool coolants and cutting oils, and in systems requiring continuous circulation of liquids. Unit is available with



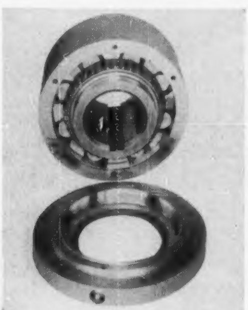
nonautomatic, fully automatic, or manual-automatic control. **Kenco Pump Div.,** American Crucible Products Co., 1305 Oberlin Ave., Lorain, Ohio.

Circle 593 on Page 19

Clutches

roller-type units are for heavy-duty applications

Free-wheeling clutches include sizes up to large shaft diameters for heavy-duty drives. They are roller-type units with no springs, insuring a minimum of free-wheeling friction. Clutches have continuous contact along entire roller length, allowing relatively small ODs for a given shaft size. Units are equipped with antifriction bear-



ings and can be furnished as couplings, with one member splined to the other, providing allowance for slight shaft misalignment. **Odin Corp.,** Castleton, Ind.

Circle 594 on Page 19

ENGINEERING DEPARTMENT EQUIPMENT

Test Oscillator

incorporates all-transistor circuitry

Model 21A pushbutton test oscillator provides eight preset frequencies within 15 cycles to 150 kc at a source impedance of less than 0.5 ohm. Unit incorporates all-transistor circuitry, printed wiring,

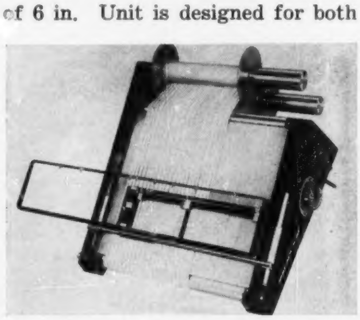
and self-contained power supply. Completely portable, instrument weighs 6½ lb and measures 6 x 8 x 6 in. **Alectra Div.,** Consolidated Electrodynamics Corp., 325 N. Altadena Drive, Pasadena, Calif.

Circle 595 on Page 19

Oscillogram Reader

handles any number of linear or nonlinear channels

Model R-1 electrically driven Data Reader handles any number of linear or nonlinear channels, correcting for linear or nonlinear scale factors, and automatically correcting for the zero line location of each channel. It accommodates film widths from 0 to 16 in. and has maximum roll diameter of 6 in. Unit is designed for both



reading and scanning. It is equipped with an adjustable-speed drive with variable transformer control; brakemotor gives instant stop. **Gerber Scientific Instrument Co.,** 162 State St., Hartford 1, Conn.

Circle 596 on Page 19

Electronic Computer

has automatic positioning of decimal point

Auto-Point 610 is a desk-side electronic computer capable of 214 additions or subtractions, and 52 divisions or multiplications per minute. A high-speed, general-purpose machine, it is completely self-contained, and includes a magnetic-drum memory. Ease of programming and flexibility make it applicable to a wide range of problem areas. Unit accepts sentence-type instructions composed of any number of individual commands, causing machine to execute entire functional operations. Computer provides automatic decimal point

control. Visual display unit shows operator any number stored in the machine. **International Business Machines Corp.,** 590 Madison Ave., New York 22, N. Y.

Circle 597 on Page 19

Magnetic Tapes

for instrumentation use are long wearing

No. 148 and 149 long-wearing magnetic tapes have applications where high tape speeds, head pressures, and temperatures to 200 F are encountered, such as in airborne and telemetering recording, computers, tape-control systems for machine tools, and geophysical recording. Smooth oxide surface results in decreased head wear.

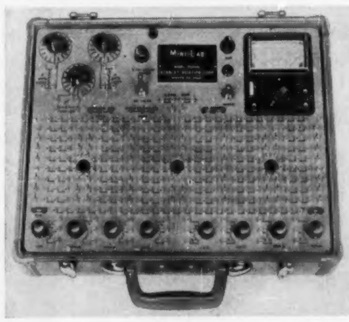
Engineering Equipment

Durable polyester backing provides maximum dimensional stability over a wide range of temperatures and humidity. Tapes contain no more than one dropout per 2500-ft roll. Tape No. 148 employs a 1.5-mil backing and is available in lengths of 1200, 2500, and 5000 ft; No. 149 has a 1-mil backing and is furnished in lengths of 1800, 3600, and 7200 ft. Both tapes are available in standard widths from 1/4 to 1 in. **Minnesota Mining & Mfg. Co.**, 900 Bush St., St. Paul 6, Minn.

Circle 598 on Page 19

Circuit-Design Unit

permits rapid circuit development



Designed specifically for subminiature, miniature, and semiconductor circuitry, Mini-Lab provides for the rapid development, assembly, study, and testing of circuits and components. It contains a grid of tiny jacks arranged in the form of tie points, voltage busses, ground busses, coupling junctions, and input and output terminals. Miniature and subminiature vacuum tubes, transistors, and other semiconductors can be plugged into the board quickly. Unit also contains regulated power supplies, built-in multimeter, selector boxes permitting a choice of 34 different resistor values and 17 different capacitor values, eight linear 2-w potentiometers, and a supply of plugs and extra jumpers. It measures 12 x 15 x 3½ in. with case opened. Cover is removable and contains an accessories storage compartment and holder for schematic diagrams. **Stanley Aviation Corp.**, 2501 Dallas St., Denver 8, Colo.

Circle 599 on Page 19

THE ENGINEER'S

Library

Recent Books

Handbook of Layout and Dimensioning for Production. *By H. H. Katz, Allied Institute of Technology, Chicago, Ill.; 479 pages, 6 by 9 in., clothbound; published by the Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$15.00 postpaid.*

Industry-defined layout and dimensioning procedures are stressed in this book. All steps in product development, from technical sketch to final drawing, are illustrated and detailed in terms of procedures, principles, and theories. The relationship of each step to efficient mass production is discussed.

Major sections include layout practices, sketching, projective and descriptive geometry, layout applications, dimensioning principles and applications, datums, and elements of gaging.

Notes on Analog-Digital Conversion Techniques. *Edited by Alfred K. Susskind; 417 pages, 6 by 9 in., paperbound; published by The Technology Press of M.I.T., Cambridge, Mass.; available from* MACHINE DESIGN, *$10.00 postpaid.*

Designed for practicing engineers, this book includes an introduction to the theory of sampling, quantizing, and coding; detailed analysis and evaluation of basic coding and decoding methods for electrical and mechanical analog quantities; and a case study showing how basic principles were applied in a digital flight-test instrumentation system.

The Elements of Physics. *By Alpheus W. Smith and John N. Cooper; 671 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

In its sixth edition, this treatise covers conventional areas of me-

Circle 470 on Page 19

chanics, sound, heat, light, electricity, electronics, and atomic and nuclear physics, but without calculus as a prerequisite. Subject matter is developed so as to make relationships between physical phenomena as apparent as possible.

Emphasis is on practical application of physics to everyday living, and many examples relate to engineering, biology, medicine, and chemistry. Electricity and magnetism sections have been rewritten and reorganized to include recent developments in physics.

Association Publications

Recommended Practice for Repair Welding and Fabrication Welding of Steel Castings. 52 *pages*, 8½ *by* 11 *in., paperbound; published by and available from Steel Founders' Society of America*, 606 *Terminal Tower, Cleveland* 13, *Ohio*, 50 *cents per copy.*

This booklet contains results of a research project conducted by Battelle Memorial Institute on the welding of steel castings. Three major sections cover welding methods, electrodes, and recommended welding procedures for carbon steel and low-alloy castings with each general alloy series extended for quick reference.

Radiation Effects on Materials. 196 *pages*, 6 *by* 9 *in., clothbound; published by and available from American Society for Testing Materials*, 1916 *Race St., Philadelphia* 3, *Pa.;* $4.75 *per copy.*

This symposium is the first of a series sponsored jointly by the ASTM Committee on radioisotopes and radiation effects and the Atomic Industrial Forum, and the papers were first presented at a meeting in 1956. The symposium is divided into three parts: Theory of radiation, radiation facilities and mechanics of testing, and experimental tests and results on fuel and graphite materials and structural materials including organics.

Data and evaluations are presented as they apply to nuclear reactor structures and components. Known properties of materials are evaluated in the light of actual reactor operating conditions.

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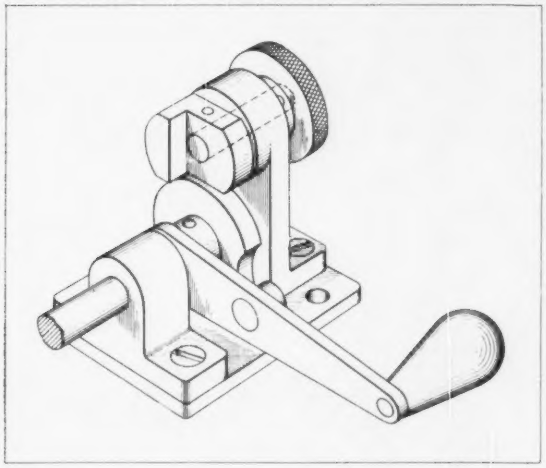
NOTEWORTHY

Patents

Manual Safety Switch

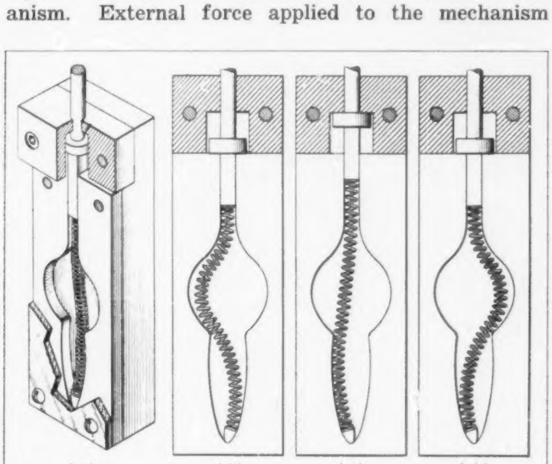
Momentary pause at an intermediate position is insured by a cam interlock in a three-position manual safety switch. For use in motor reversing and similar



operations, the switch locks when the operating lever is moved from an extreme to the straight-up position. Operator releases arm for continued motion to the opposite extreme by rotating the locking cam by means of a knurled knob. *Patent 2,809,537 assigned to General Electric Co. by William H. Jette.*

Bistable Spring Mechanism

Controlled bowing of a helical compression spring against the walls of a shaped cavity gives two positions of plunger stability in a bistable spring mechanism. External force applied to the mechanism



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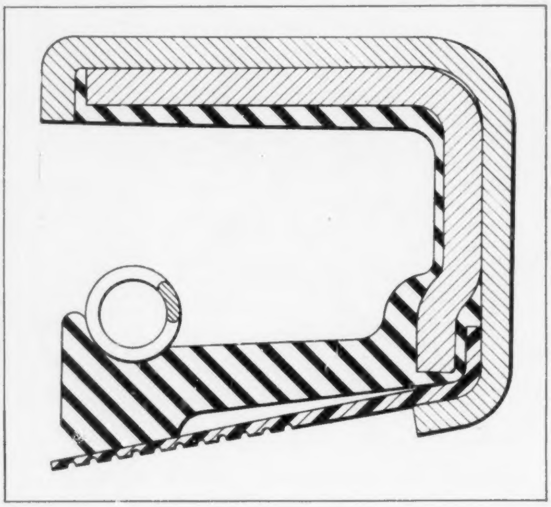
Noteworthy Patents

plunger forces the spring from the first stable position, *a*, to the unstable sinusoidal configuration, *b*. Spring then snaps spontaneously to the second stable position, *c*, returning plunger to its initial position. Beginning of next cycle of operation is shown at *d*. *Patent* 2,802,365 *assigned to Burroughs Corp. by Martin F. Hoepfner.*

Radial Seal

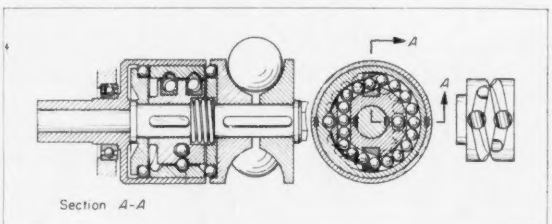
Auxiliary sealing sheath of Teflon, interposed between elastomer seal body and rotating shaft, permits leak-free elevated-temperature operation of a



spring-loaded radial seal. Spirally grooved for flexibility and leakage-return pumping action, the sheath minimizes age hardening of elastomer seal components due to shaft eccentricity or runout. *Patent* 2,804,325 *assigned to General Motors Corp. by Ellwood F. Riesing.*

Ball-Screw Unit

Internal return passages, drilled in a helically grooved male member (right), recirculate balls with no jamming in a low-friction ball-screw unit. Torque



applied to the unit input shaft (left) forces the male member to translate axially by thread action of the helical grooves and coupling balls. Axial-motion takeoff in unit shown is through large balls at right end of section *A-A*. *Patent* 2,802,373 *assigned to Roller Gear Co. Inc. by Henry Schottler.*

THE INDEX

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BPA NBP

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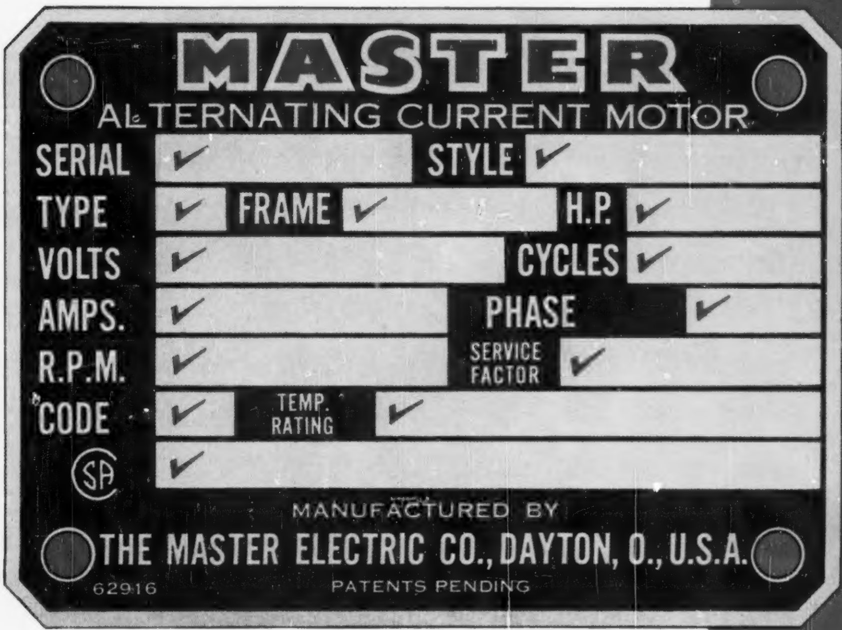

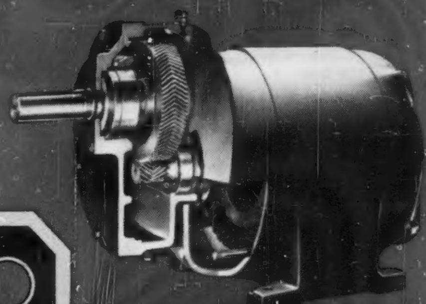
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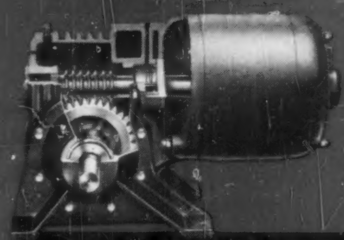
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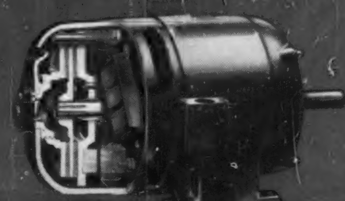
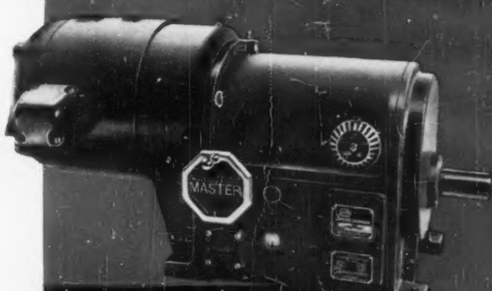

Unibrake Motors



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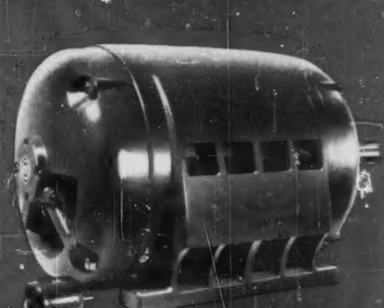
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Need something special in gear reduction—electric brakes—variable speed operation—fluid drive or special mounting? Or would some of our standard models (1/8 to 400 H.P.) fill the bill? You'll find the answer here! And remember, all Master components are engineered to form combinations of units in one streamlined, compact package of efficiency. Name your need and the name that fills it is Master—for greater salability of motor driven products; for increased productivity of plant equipment.

Motor Ratings	1/8 to 400 H.P. All phases, voltages and frequencies.
Motor Types	Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.
Construction	Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.
Speeds	Single speed, multi-speed, and variable speed.
Installation	Horizontal or vertical, with or without flanges and other features.
Power Drive Features	Electric brakes (2 types)— 5 types of gear reduction up to 432 to 1 ratio. Mechanically and electronically-controlled variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

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